

**PRIMARY TEACHERS' ATTITUDES
TOWARDS MATHEMATICS AND MATHEMATICS TEACHING
WITH SPECIAL REFERENCE TO A LOGO-BASED
IN-SERVICE COURSE**

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Abstract

This thesis investigates primary teachers' *attitudes* towards mathematics and mathematics teaching, and whether or not they are amenable to change. As used in the study, the term focuses on people, objects and issues, and brings together thought, action and emotion.

The purpose of the research was threefold :

- to investigate primary teachers' attitudes towards mathematics and towards mathematics teaching, and as a subsidiary aim to examine factors that might account for these attitudes;
- to examine ways in which primary teachers' attitudes towards mathematics and mathematics teaching, along with other factors, influence their participation in a Logo-based mathematics in-service course;
- to ascertain the degree to which primary teachers' attitudes towards mathematics and its teaching are influenced by their participation in a Logo-based mathematics in-service course.

A two-country "zoom lens" design was adopted. It consisted of two qualitatively distinct but related sub-studies: (1) an attitude survey making use of a self-administered questionnaire; and (2) a developmental study of attitude change based on a Logo-based mathematical in-service course. These issues were investigated by adapting a vantage point which spans two educational cultures: England and Portugal.

The attitude survey was administered in England in the Autumn term of the 1987/88 academic year and involved all the primary teachers of Suffolk County Council. In Portugal, it was administered in the Spring term of the same academic year and involved all the primary teachers in the district of Viseu. The attitude questionnaire used in the survey included several Likert-type scales aimed at mirroring different aspects of primary teachers' attitudes towards mathematics, as well as questions which sought to gather information about the teachers' background.

The second sub-study was carried out in Portugal in the Summer term of the academic year 1987/88, and in England in the Autumn term of the following academic year. It involved ten

Portuguese primary teachers and seven English primary teachers who volunteered to attend the Logo course. The methodology used in this sub-study combined ethnographic methods and concepts with principles akin to an action research paradigm.

Considering the two sub-studies as a whole, the two most important conclusions were the following. First, the study indicated that the attitudes towards mathematics and mathematics teaching of the English primary teachers differed considerably from those of the Portuguese ones, along with their interactions with the Logo course, thus implying that cultural, social and even political factors are relevant to teachers' attitudes. Second, when the participation of the teachers in England and Portugal were compared (not in absolute, but in relative terms), there was a fair degree of similarity as to the conclusions reached in the two countries. The following conclusions were drawn: (a) Shifts in the teachers' attitudes towards mathematics and mathematics teaching were more likely to occur when they were already committed to change at the beginning of the course; (b) Shifts in the teachers' attitudes towards mathematics and mathematics teaching were closely related to the sense of personal achievement they derived from the course.

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CHAPTER 1

Mutability

(Introduction)

Times change with seasons, men too change their mind
We change the way we are, the way we feel:
Everyone, and everything is changeable
Made to take on the new in every kind.

Camões¹

During the last decade or so, there has been a resurgent interest in researching teachers' thought processes and implicit theories about mathematics and mathematics teaching. The purpose of this study was to provide further information about these issues by adapting a vantage point which spans two educational cultures: England and Portugal. The key term used to describe teachers' personal thought processes and implicit theories about mathematics and its teaching is *attitudes*. The choice of this term presupposes the view that, in addition to cognitive factors associated with mathematics, affective variables play an important role in informing teachers' practices. I decry with Bruner (1986) "the habit of drawing heavy conceptual boundaries between thought, action and emotion as 'regions' of the mind, then later being forced to construct conceptual bridges to connect what should never have been put asunder" (p. 106).

The purpose of the research was threefold:

- to investigate primary teachers' attitudes towards mathematics and towards mathematics teaching, and as a subsidiary aim to examine factors that might account for these attitudes;
- to examine ways in which primary teachers' attitudes towards mathematics and mathematics teaching, along with other factors, influence their participation in a Logo-based mathematics in-service course;

¹ This is part of the translation of the poem *Mutability* of Luís de Camões (c. 1524-1580), the 'national poet' of Portugal, published in Taylor, 1990.

- to ascertain the degree to which primary teachers' attitudes towards mathematics and its teaching are influenced by their participation in a Logo-based mathematics in-service course.

In this chapter, I consider first the background to the study, by stating how I became interested in its general topic. Then I will set the scene for the study by focusing attention on the two broad educational contexts in which the investigation took place.

BACKGROUND TO THE STUDY

First steps into the problem

Meeting the Turtle

My experience with Logo began in 1984. I had enrolled in a Masters degree course in mathematics education, which would allow me to gain a post as a mathematics trainer of prospective primary teachers in Portugal. Although computers had not been introduced in Portuguese schools yet, I sensed that a mathematics course for primary teachers would have to include some kind of information about how to use computers in their mathematics teaching. Lacking that kind of information myself, I sought out people who could give me guidance. At their suggestion, I read Papert's (1980) book *Mindstorms* and I introduced myself to Logo. My response to both Logo and *Mindstorms* was very enthusiastic. My strongest impression from working with Logo was that I was doing mathematics in a way that I had never previously done. The intellectual pleasure that I used to feel from playing with mathematical objects or of being able to come up with a rigorous proof had given place to a fascination with the freedom to explore and think divergently. From reading *Mindstorms* I derived a deep understanding and appreciation of the forces affecting the teaching and learning of mathematics. As a teacher of and a lecturer in mathematics I had been most influenced by a tradition that placed strong emphasis on the formal and rigorous aspects of the subject and on a 'delivery' teaching style, and I was beginning to realise that there could be a new way of looking at both mathematics and mathematics teaching. It was probably not something that just came from the experience with Logo, but the experience with Logo certainly helped.

As a result of my own experience with Logo, I decided that, in my Masters thesis, I would put forward the case for making Logo part of the prospective primary teachers training courses (Moreira, 1984). In fact, in the academic year of 1985/86 when I started my new job as a primary teacher trainer, I had the opportunity of applying, at least partially, the ideas developed in my Masters thesis to two groups of students who were taking a course in mathematics. This

experience reinforced my preconception of the potential of Logo to create a teaching/learning atmosphere different from that I was accustomed to both as a learner and a teacher of mathematics, and possibly to instil a novel mode of thinking about the subject (Moreira, 1986).

Two modes of thinking about mathematics and mathematics teaching

Let me state that I did not completely change my view of mathematics, neither did I abandon totally my old style of teaching. Along with that experience of introducing the student-teachers to Logo by using what I may call a 'new' approach to teaching, I was still teaching them some elements of Linear Algebra using the 'old' approach or hopefully a slightly different version of it. My first experience with Logo had contributed to making me realise that there were two modes of thought about mathematics and its teaching, whereas before I only knew one way of thinking; but it did not make me feel that that the 'world' where I used to live was worthless.

The point in relation to mathematics and its teaching is similar to that of Bruner's (1986) in referring to literature:

A good story and a well-formed argument are different natural kinds. Both can be used as means for convincing another. Yet what they convince *of* is fundamentally different: arguments convince one of their truth, stories of their lifelikeness. The one verifies by eventual appeal to procedures for establishing formal and empirical proof. The other establishes not truth but verisimilitude. It has been claimed that the one is a refinement of or an abstraction from the other. But this must be either false or true only in the most unenlightening way. (p. 11)

In drawing a contrast between two modes of thinking, I do not want to place one perspective as superior to the other, but to point out that there might be different issues and assumptions that can significantly influence understanding of what mathematics and mathematics teaching/learning is about.

Expanding awareness of mathematics across two countries

I also came to get the impression, as a result of both my long experience as a learner and teacher of mathematics in Portugal, and of my brief encounter with mathematics educators in England, that the whole conception of mathematics education and views of the 'proper' ways of doing things may be different in these two countries. For example, it appeared to me that ideas of child-centred, problem-solving and discovery learning in mathematics tended to be more firmly rooted in England than seemed to be the case in Portugal. If that was so (and I do not wish to exclude the possibility), would I have been so much impressed by reading *Mindstorms* and meeting the Turtle if I had been a learner and teacher of mathematics in England?

Of course, that question has to be left unanswered. There is, however, little doubt that culture influences and is influenced by the modes in which people think and behave, and the same may

be said in relation to education. With regard to mathematics, although there has been a widespread belief that it is 'culture free', the view is emerging that it "need not necessarily 'look' the same form one cultural group to another" (Bishop, 1988). Earlier in this section I mentioned two modes of thinking about mathematics and mathematics teaching of which I became aware as a result of my encounter with a new tool in my own culture. Here, I am talking about expanding my awareness of mathematics as a result of my induction into a culture which was different from my own. This naturally raises other kinds of educational issues, which like the previous ones are worthy of investigation.

Rethinking rethinking mathematics education

The above is a quite personal experience of rethinking mathematics education and of the important role that the computer and Logo might have had in leading me to do so. I believed, however, that the two issues, the need for rethinking mathematics education and the use of computers in schools, served well as points of departure for an investigation. In fact, it is now almost a commonplace within the mathematics education community to present a case for rethinking, if not reshaping, the kind of mathematics teaching and learning that takes place in schools.

The case for change, however, is not new. Now and then, attempts to reform school mathematics have been made, the most well-known of which was, by its universality, the 'new maths' movement of the 1960s. Calling for change is not surprising... it is inevitable -- *Times change with seasons, men too change their minds.*

Now, it has been well documented that in spite of several calls for change in mathematics education, this most often does not take place. An account of this situation is given, for example, by Lunn (1984). From reviewing several studies undertaken in British primary schools, he concluded: "the emphasis on mathematical computation was still the same in 1965 and 1980" (p. 187). If efforts to bringing about change in mathematics education have been failing, it seems reasonable to suggest that what it is necessary is rethinking rethinking mathematics education. Problems of implementing change, however, are not specific to mathematics, though they might be compounded within this subject. For example, one may find parallels between the idea of rethinking rethinking mathematics education and that of Olson's (1985) suggesting "changing our ideas about change" (p. 294). Olson's case rests on the view that change in schools hardly takes place unless teachers, who are the ones responsible for implementing change, become aware of the need for change by first reflecting critically upon their existing practices. Indeed, one cannot assume that simply bringing new pedagogical ideas to teachers will enable them to grasp the underlying structure of those ideas,

and that they will be able to implement them. Instead, it seems quite plausible that teachers will sieve the new ideas through their own cognitive and emotional filters --*We change the way we are, the way we feel.*

Credit belongs to other researchers, too, for suggesting both the importance of teachers' knowledge and thought processes in making sense of new pedagogical ideas, and the need for teachers become aware of their subjective beliefs about subject matter and its teaching. For example, Clark and Peterson (1986) in reviewing research on teaching concluded that:

if teachers' implicit theory about learners or their mental image of effective teaching were contrary to that embodied in a new curriculum or an experimental teaching method, they would be unlikely to bring the Innovation alive with great enthusiasm, thoroughness, and persistence. (p. 292)

In similar vein, within the mathematics education community the role of teachers as agents of change has been stressed. An implication of this is that a possible answer to rethinking mathematics education lies in rethinking teachers' mathematics education. Within this perspective, a fundamental strategy for rethinking mathematics education is to attempt first to change teachers' attitudes towards mathematics and mathematics teaching. This view has prompted mathematics education researchers to devise staff development programmes in order to help teachers to construe their practices more efficiently by having their attention drawn to their views about mathematics and mathematics teaching (e.g. Fennema, Carpenter and Peterson, 1989; Hoyles, Noss and Sutherland, 1991).

Computers as catalysts for rethinking mathematics education

Let me approach the matter of rethinking mathematics education from the perspective of the introduction of computers in schools. Following initial scepticism, there now seems to be a widespread acceptance of the use of computers in education on the part of teachers and educationalists, pupils and parents, society and governments. The idea that *everyone, and everything is changeable* may be well applied to describe this phenomenon. As Mitchell (1983) suggests "it is no longer a question of should computers be used in schools but rather of how should they be used" (p. 2).

Computers have been recognised as having the potential to provide a qualitatively new tool for pupils learning mathematics. For example, Hoyles (1989) claims on the basis of classroom evidence that computers can be used:

as a means to create a new type of environment for learning mathematics which puts value on pupil investigation and independent learning, embeds mathematics in a new,

interactive and exciting medium and bridges the gap between actions and their formalisation. (p. 55)

In line with the discussion in the previous section, Hoyles went on to point out the problems of implementing change and the need for teacher education. However, she also suggests that the potential of the computer to bringing about change is more likely to be realised than with previous initiatives because of the large consensus that now exists about its use in school.

On capitalising on the interest that teachers may have in using the computer, I restate Olson's (1985) idea: providing teachers with the help and support they need to become confident with the new tool, and offering them a 'new' mathematics pedagogy may well encourage them to reflect critically on their practice, and question their feelings and old beliefs about the subject and its teaching.

Logo and mathematics

Of all kinds of computer-based environments that may reshape mathematics education, Logo stands out as the one with greatest potential for revolutionary impact. In his seminal work, *Mindstorms*, Papert (1980), one of the developers of Logo, argues that the computer and Logo would provide a suitable environment for children to be involved in meaningful mathematical activities, as well as to construct knowledge and understanding about mathematics ideas and concepts, and develop problem-solving skills.

Papert's claims have generated a great deal of research focusing on children working with Logo and on the possible cognitive and affective benefits associated with learning mathematics. However, findings on the effectiveness of Logo are mixed (for a review of recent research see, for example, Krendl and Lieberman, 1988). In particular, there is some controversy about whether pupils working with the Logo turtle are engaged in mathematical activity or 'just' using it to draw. In my opinion, there is a considerable deal of utopia in Papert's (1980) metaphor of the computer and Logo as a mathland according to which pupils would learn mathematics in the same way as they learn how to speak their mother tongue. But I also disagree with the idea that Logo is just a drawing tool. Indeed, in order to make the turtle draw, children have to use a formal language to represent what they want to draw, as well as having to ascribe meaning to symbols that are traditionally associated with the language of mathematics -- the numbers. To say that a pupil who is able to represent a circle by writing an equation of the type $x^2+y^2 = 1$ is engaged in mathematical activity, and that one who writes REPEAT 360[FD 1 RT 1] to draw a circle is not, seems to be purely arbitrary and can only be understood in light of the previous existing mathematical culture.

One may refer to Logo as *made to take on the new in every kind*, from 'just' drawing or manipulating symbols without understanding, to engaging in highly sophisticated mathematics. My standpoint is along the same lines as that expressed by Weir (1989):

Students do not, typically, on their own, gain an appreciation of the formal significance of the operations they are performing. The wider application of those operations needs to be made apparent to them; their meaning needs to be explicated. (p. 62)

How to get to Logo mathland?

While the *mathland* metaphor may be useful in indicating that Logo has the potential to establish a link between concrete and intuitive mathematics, and the formal one, and to render pupils' mathematical activity meaningful and creative, this metaphor may be relevant in a more enlightening way. An analogy with a land where the majority of the population share the same culture and same language comes to mind. One of the possible reasons why children may not come to speak mathematically within a Logo environment is that the language of the *mathland* is not shared with that of teachers, parents and people at large. In the classroom setting, teachers spend time with pupils introducing them to their mathematical culture. No wonder pupils fail to speak the language of the Logo *mathland* if this is not part of the teachers' culture. Teachers therefore need to become familiar with the *mathland* culture and language, so that they can help pupils to take part in that culture.

It is important to realise that probably not every teacher will be able to enter the new culture. Entering the *mathland* culture means not only learning the Logo language, but also becoming familiar with a new way of looking at and doing mathematics. The extent to which teachers are prepared to enter such culture may be subject to social, cognitive, and affective factors. Take as an analogy the experience of a foreigner "Lost in Translation" (Hoffman, 1989) who comes to live a new country and has to recreate herself in another culture. First, teachers must perceive the need to move to another culture. Second, they have to be cognitively ready to learn the new language and accept the new culture. Finally, they have to hold a positive attitude about themselves so that they can compensate for the pressures and difficulties faced as a result of acculturation.

To help teachers to enter the new culture, in which the computer and Logo are to be converted into tools for a new kind of mathematics learning, it is essential that they have time and support both to develop confidence in using the new tools and to have a clear vision of what constitutes the new learning. In-service training has been widely adopted as a way of preparing teachers to implement educational change, although whether and what kind of in-service provides an

effective route to bring about change at school level is still an object of controversy (Fullan, 1982).

Mathematics and culture

Let me sum up the argument so far. On the one side, there is a need for rethinking rethinking mathematics education. On the other, today's pervasive use of computers in society may create a climate amenable to change in schools. One very important aspect common to the two premisses is that of the role of the teacher in influencing both the way mathematics is taught and computers are used in the classroom. Another link between the two claims which seemed fruitful to pursue is that provided by the Logo computer language. As the argument developed, the question of rethinking rethinking mathematics education led to the idea of examining teachers' attitudes towards mathematics and mathematics teaching, and introducing them to a Logo-based mathematical culture as a means of doing so.

I want now to pursue my argument further. Initiation of teachers into a new mathematical culture is difficult and may depend on the extent to which their previous mathematical culture is in tune with the new one. As discussed earlier, it is no longer the case, at least among the mathematics education community, that mathematics and mathematics teaching are thought of being 'culture-free'. Several cross-cultural studies have provided some evidence that culture intrudes on the teaching and learning of mathematics (for a brief review see, for example, Stigler and Perry, 1988), and there are also a few personal accounts of the interaction between mathematics instruction, and established cultural patterns of belief and thinking (e.g. Fasheh, 1982). However, there is still much work to be done to come to understand how cultural factors impinge on mathematics education, and one of the areas that has been most neglected by previous cross-countries research is that of teachers' attitudes towards mathematics and mathematics teaching.

Moreover, as Huberman (1973) put it, the process of change in education, like education itself, can be best understood if one takes into account three units of analysis: the individual as adopter, the group as key parameter, and the institutional and cultural framework. His point is that whether or not an individual responds to a call for change is partly due to his/her own characteristics and partly shared with the elements of the group to which the individual belongs. The group, in turn, has its own features which can be thought of as facilitating or inhibiting change. Finally, the group shares with other groups in the same country characteristics which are inherent to the country culture. The relative similarity of the body of mathematical knowledge taught across countries makes the role of the culture especially prominent. It is, then, suggested that a study of teachers' attitudes and attitude change that

spans two considerably different countries, such as England and Portugal, leads to a more explicit understanding of the processes underlying those phenomena than if it was undertaken in only country.

OVERVIEW OF THIS THESIS

For clarity, I present here a plan of this dissertation. It will help the reader to have right at the start a quick overview of what this research was about and what major processes were involved in undertaking it. The dissertation is organised into seven chapters. Following the previous sections which provide the background to the study and its general goals, the remainder of the present chapter sets the scene by describing the two broad contexts in which the research was undertaken. Chapter 2 presents a review of literature related to the field of enquiry. It includes two sections corresponding to a theoretical review of two distinct fields: (a) perspectives on attitudes and attitude change; and (b) perspectives on in-service education and training of teachers. In addition, the chapter presents a review of relevant research concerning: (1) teachers' attitudes towards mathematics and the teaching of mathematics; and (2) teachers' learning and teaching experiences with Logo. Chapter 3 provides a detailed outline of the research and of the methodological issues associated with it. The research consisted of two sub-studies, an attitude survey aimed at providing information about primary teachers' attitudes towards mathematics and its teaching, and a study aimed at investigating how primary teachers interacted with a Logo-based mathematics in-service course and how their attitudes were affected by their participation in the course.

Chapter 4 provides an overview of the research tools to assess teachers' attitudes towards mathematics and mathematics teaching, as well as the procedures involved in their development. These include the attitude questionnaire used in the attitude survey and the pre- and post- interviews carried out with the participants in Logo-based mathematics in-service course. Moreover, Chapter 4 is devoted to the design of the Logo in-service course.

Chapters 5, and 6 provide the findings of the two sub-studies. Chapter 5 reports on the findings of the attitude survey sub-study. The results presented in the chapter were drawn from an analysis of data carried out by use of the SPSSX package for statistical analysis, involving both descriptive statistics and multivariate analysis. Chapter 6 reports on the findings of the attitude change sub-study which has for basis a Logo-based mathematic in-service course. It attempts to give a picture of teachers' attitudes towards attitudes towards mathematics, the teaching of mathematics and use of computers in mathematics lessons both before and after the course, as well as the characterisation of their interactions throughout the course. It also offers systematically derived explanations about why those interactions occurred. The principles and techniques of analysis followed a qualitative paradigm, consisting of what can be called cross-

case analysis. Moreover, it presents the cases of four of the course participants who seemed to be motivated to change prior to the course.

The dissertation ends with Chapter 7 which provides a reflective and integrated summary of the findings of the two sub-studies. The chapter also includes the limitations of the study, as well as some suggestions for further research and educational implications.

CONTEXTS OF PRIMARY MATHEMATICS EDUCATION IN ENGLAND AND PORTUGAL

The main objective of this section is to provide an understanding of some of the cultural and contextual factors which are likely to influence primary teachers' attitudes towards mathematics and its teaching, in both England and Portugal. It should be noted in passing the absence of any rigorous study of comparative education involving the two countries on which to base the present comparison. The section is then organised around a range of issues which in my opinion are most relevant to this study. These include a brief description of some of the salient features of the educational systems, and an overview of primary teacher education provision both at pre- and in-service level. The section ends with an examination of relevant developments that have taken place at the level of mathematics education both recently and in the past.

Overview of the educational systems in England and Portugal

Several studies of past and current educational systems in England and in Portugal are readily available (for Portugal see, for example, Silva and Tamen, 1981; Rocha, 1984). A brief account of a few topics directly related to the theme of this thesis will suffice here.

It should be stressed that the educational systems in the two countries recently underwent through considerable changes. In England, a new Education Act was passed in 1988, and in Portugal the new law of "Bases do Sistema Educativo" was approved in 1986. Most of the present account is in reference to the two countries educational systems before these reforms. The main reason for so doing lies in the fact that the fieldwork carried out as part of the present study took place in a period in which those reforms were hardly implemented.¹ One may surmise that the effects of such reforms on teachers' attitudes towards mathematics and

¹ The fieldwork took place in Portugal during the academic year of 1987/88 and in England during the academic years of 1987/88 and 1988/89.

mathematics teaching is considerably weak as compared to the influence of the previously existing educational contexts.

Control of education

The two countries provide interesting situations for comparison since they have been systematically different with regard to the control of education. England, whose educational system is idiosyncratic in many aspects (see, for example, Nicholas, 1983), has often been taken as an instance of highly decentralised educational administration. In Portugal, in contrast, there has been a great emphasis on the control of education by central government (Martins, 1981).

Note in passing that in what may be seen as a tendency of the present time (Broadfoot, 1985), the two countries seem to be moving in two opposite but convergent directions. In England, the movement is towards a greater centralisation with the government "now dictating policy and using a variety of tactics to achieve compliance" (Nicholas, 1983, p. 170). The changes in Portugal may be characterised as leading to what Lyons (1985) calls *deconcentration* : "the centre retains the main elements of strategic control of the system, but the scope of planning, decision-making and control at the local and/or other sub-national levels of the system is enlarged" (p. 87).

School structure

A comparison of the school structure in the two countries can be made by providing a diagrammatical representation (see Figure 1.1 and Figure 1.2). As suggested by the diagram, it is not easy to state how compulsory schooling (age 5-16) is structured in England. Flowing from a very low degree of centralisation, the functions of schooling have been under the responsibility of local educational authorities (LEAs) which have proceeded in different directions. Thus, there has been a variety of types of schools at both *primary* and *secondary* level, and even what is meant by the terms primary and secondary is not consistent nationally. A widespread pattern corresponds to considering *primary* schooling as that corresponding to the 5 to 11 year age range. Quite often, primary schooling takes place in two different types of schools: infant schools (5-7) and junior schools (7-11).

The school structure in Portugal is comparatively simpler. In 1964, compulsory schooling was extended from four to six years. It corresponded to four years of 'ensino elementar' and two years of 'ensino complementar' (fifth and sixth grades). Alternatively, these two latter years could take place in two different ways: in '*escola preparatória*' or through TV transmitted lessons (Fernandes, 1981). At secondary level, there were in the past three distinct types of schools leading to different terminal certificates: *liceu*, *escola comercial*, and *escola industrial*.

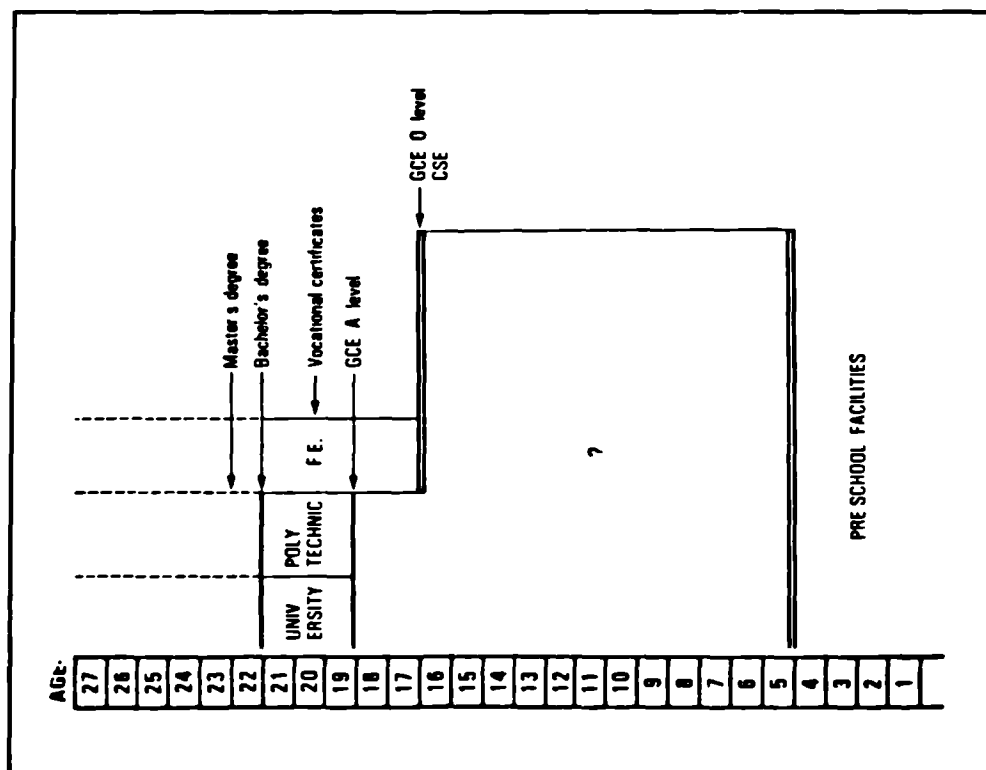


Figure 1.1: The education system in England and Wales.
Source: Nicholas, 1983.

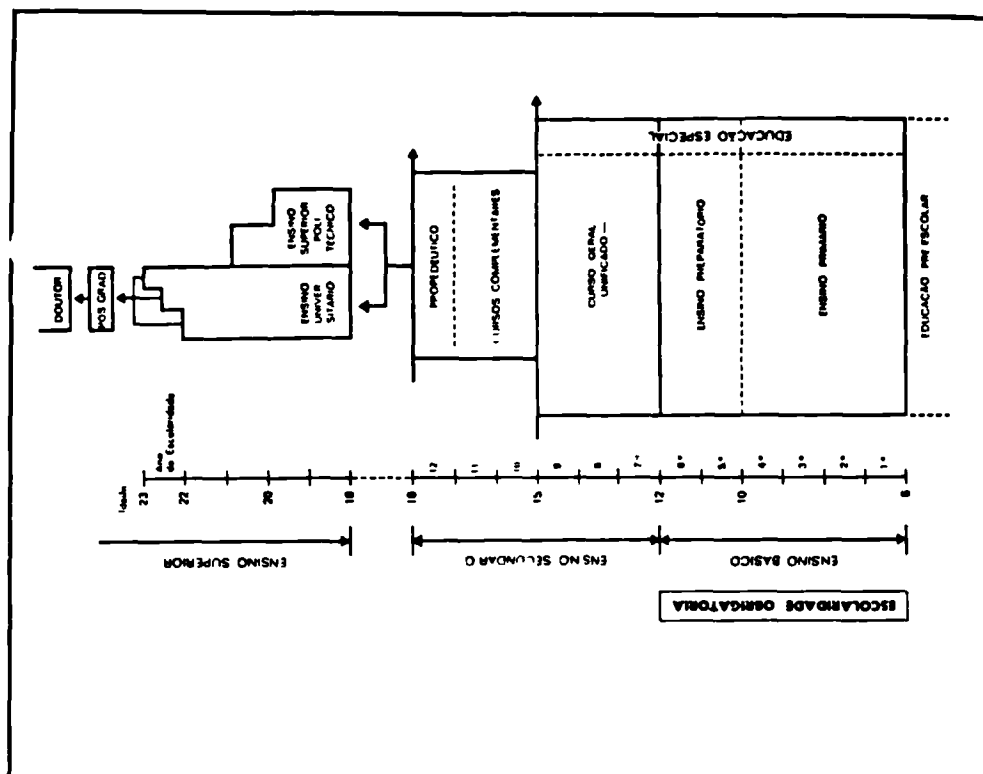


Figure 1.2: The education system in Portugal.
Source: Costa, 1981.

After the political revolution in 1974, the government established a unified system of secondary schooling (Emfido, 1981).

It is important to note that whereas in England children's age is used to demarcate the different types of schooling, in Portugal the schooling is organised in cycles. Thus, the primary school cycle is four years long, but children may have to repeat a year if their attainment level is unsatisfactory, and therefore the ascription of chronological age to the various grades is entirely nominal. It may be worth mentioning, too, that as a consequence of such policy children may well leave school without having completed the full range of grades of compulsory schooling.

Finally, it should be emphasised that in line with the high degree of centralisation of the educational system in Portugal, school curricula have been nationally determined. In England, in contrast, school curricula were established (until the new Education Act was passed in 1988) by the individual schools along the lines provided by the LEAs

Examinations

Another way in which the educational system in England has differed greatly from that in Portugal has been in the focus put on the assessment of pupils' achievement. The aims of English education at every level have tended to emphasise overall human development rather than producing the state's manpower needs. In thinking of ways of assessing pupils, there has been more concern with "promoting quality in certain subject areas offered by the schools" (Cummings, 1990, p. 93) than in assessing the amount of knowledge acquired by the pupils. During the compulsory period of schooling, pupils progress automatically through the different years. There was, nevertheless, an examination system in England prior to the 1988 Education Act. It was centred for many years around three exams: (1) the 11-plus examination taken by 11-year-old children with the purpose of selecting them for the grammar schools (this practice has been meanwhile abandoned by most of the LEAs); (2) the GCE O-levels (ordinary examinations) taken by pupils at the end of compulsory secondary education (age 16); and (3) the GCE A-levels (advanced examinations) taken at the end of the two year cycle that follows the compulsory education. The O-level and A-level examinations were offered by the Universities examining board, and pupils had a variety of choices (for example the University of London used to offer four separate options in O-level mathematics) and could take as many of these examinations as they wished. In turn, as Nicholas (1983) suggests teachers used to "select those boards who examine what they prefer to teach" (p. 142) rather than teaching what the boards preferred to examine.

The picture in Portugal is quite different. Generally speaking, for each grade and for each subject pupils have to attain standards determined by the prescribed curriculum (but largely

interpreted by the individual teachers). Thus, there are frequent tests throughout each school year, as well as at the conclusion of each grade. Pupils failing to attain those standards have to repeat that grade the following year. The sifting of pupils was even more intense prior to 1974. There were, then, at many stages of schooling, examinations devised by the Ministry of Education across all subject areas. For example, throughout the seven grades that were included in the *liceu*, pupils had to take five examinations at the end of second grade, nine examinations at the end of the fifth grade (equivalent to O-level), and six exams at the end of the seventh grade (equivalent to A-level). Pupils were tested with both written and oral examinations, and for each subject a mark that ranged between 0 and 20 was given. The importance of these examinations and marks cannot be overlooked. Indeed, in addition to allowing pupils to pursue schooling and have access to University, passes in these examinations (corresponding to obtaining a mark of 10 or more) were, for example, a prerequisite for obtaining government posts and other jobs.

The training of primary teachers in England and Portugal

Initial training

There have also been considerable differences between the types of initial training offered to prospective primary teachers in England and Portugal. Of particular interest is the diversity of institutions and routes to becoming a primary teacher in England as opposed to the unique institutions and ways existing in Portugal. To give just a flavour of the contrast between the two countries, in England, since the late 1960s four categories of institutions (Colleges of Education, Colleges of Higher Education, Polytechnics and Universities) have been providing two different forms of training, thus allowing for a variety of patterns of programmes (McNamara and Ross, 1982). One consists of a degree course leading to the award of Bachelor of Education (B.Ed.). An alternative route consists of a one year post-graduate certificate of education course (PGCE), carried out by the candidate already holding a subject-based degree. Prior to that, teachers were trained in Teacher Training colleges, a separate sector of post-secondary education, and were awarded a Certificate of Education.

In Portugal, until the mid 1980s, primary teachers were trained in institutions that were not part of the Higher Education sector -- the *Escolas do Magistério Primário (EMPs)* (Vaza *et al.*, 1986). From the mid-1980s onwards, the EMPs were abolished, and the initial training of primary teachers has taken place in the *Escolas Superiores de Educação (ESEs)* which are part of the Polytechnic Institutes (state higher education institutions operating independently of the universities). It follows from the time period over which the present research was carried out that the great majority of the Portuguese participants in the study would have been trained in

those former schools (EMPs), and therefore policies corresponding to the initial training of teachers in the new ESEs are not considered here.

Behind the heterogeneous versus homogeneous nature of the training institutions in the two countries, lies another factor: that of the isolation of the primary teacher trainees in Portugal from experiences provided for those training for other professions (including secondary teaching). This has important implications, namely, at the level of socialisation of primary teachers, in relation to their status (as compared with that of secondary teachers in most cases holding a University degree), as well as with regard to the lack of flexibility to move to another profession. In England, primary teachers are trained in the same institutions as secondary teachers, and therefore problems concerning their socialisation, status and flexibility to abandon the profession are likely to be less acute than in Portugal.

Another significant difference concerns the aims and structure of primary teachers' initial training programmes. In Portugal, throughout the long period that preceded the intended reforms of the early 1970s, one of the main aims of the EMP programmes was to produce teachers who were able to serve the ideology of the government: a conformist and ill-educated population should not be taught by a non-conformist and well-educated class of professionals. Thus, the curriculum extended by a period of two years integrated courses such as 'Moral and Civic Education' and 'Political and Administrative Organisation of the Nation', but it did not include the study of any academic subject, neither did it include specific subjects methods courses (Cortês, 1988). Following the political revolution in 1974, the curricula of the EMPs were greatly altered. An important development was the shift from a two-year to a three-year course. The reforms also had implications at the level of mathematics education. First, the new curricula tried to integrate the academic and professional education of teachers and gave special emphasis to academic subjects such as Portuguese and mathematics (Vaza *et al.*, 1986). Second, in line with the 'new-maths' approach which had been introduced to the primary school curriculum, the programme of mathematics in the EMPs was based on the idea of formalism and rigour and, for example, ascribed little importance to geometry.

In England, with the diversity of institutions that have provided training for primary teachers, it is difficult to speak of general aims and structure of the courses. In referring to the institutions that provide a B.Ed. degree, McNamara and Ross (1982) state: "Each institution has a logic of its own, a particular history, a distinctive tradition and its set of own values" (p. 18). The disparity of the institutions to prepare primary teachers notwithstanding, the training courses have had (since 1960) a minimal duration of three years and have included both professional and academic subjects. According to McNamara and Ross, the current tendency is to re-design B.Ed. programmes in such a way to lay greater emphasis upon professional aspects. Alongside

this tendency, all the B.Ed. students preparing for teaching the primary school years range follow one main academic subject in some depth (DES, 1983). The justification for this may lie in the trend to encourage the training of primary teachers who might have an advisory role (called subject *co-ordinators*) in specific curriculum areas in their schools (Gammage, 1986).

In-service training

Along with the relatively little importance attributed to the initial training of primary teachers in Portugal was the almost total absence of continuing education for primary teachers during the long period that preceded the 1970s. During this period, content did not change and pedagogical matters were considered irrelevant. At that time, as Cortesão (1988) put it, "to be a teacher is, more and more, to transmit subject matter" (p. 87). As a consequence, there was no need for teachers to continue their education. Participation of teachers in pedagogical conferences was even not encouraged. When held, these conferences were under the complete control of the Ministry of Education, and only inspectors (and teachers designated by them) had the right to present talks (Mónica, 1978). This pattern was only broken in 1966 as a result of the shift from four to six years of compulsory education. Then, the provision of a full programme of in-service education to be held in the EMPs for primary teachers who were interested in teaching the two new grades was seen as essential by the Ministry of Education (Cortesão, 1988). Obviously, such a provision of in-service courses for primary teachers was seen as a means of ensuring that teachers could learn the new content rather than aiming at improving practice in the classroom. In similar lines, the prospect of the introduction of 'new maths' in primary schools in 1973 led the Ministry of Education to provide in-service courses on this new area for primary teachers (Matos, 1986).

Following the political revolution of 1974, the Ministry has recognised the need for teachers' continuing education and has established conditions for fostering it. Texts and audio-visual materials concerning the new content and methods were published. Regular in-service courses were organised by the Ministry of Education and teachers' associations, as well as by the EMPs. One of the most significant trends was the creation of *Centros Regionais de Apoio Pedagógico* for supporting teachers in several curricular areas (Almeida, 1979). However, such initiatives were far from effective. As Cortesão (1988) suggests "all of this has not been enough to alter habits acquired for many years, to inform people who have been isolated and not accustomed to discuss and share opinions and problems" (p.126). This might be especially true for primary teachers, as "primary teaching is an issue that concerns just primary teachers, and at most the parents of primary school children" (Almeida, p. 429).

A quite contrasting development took place in England. As stated in the Plowden Report "rapid revolutions are not common in English education" (HMSO, 1967, cited in Moon, 1986,

p. 128). Owing to the high control exercised by headteachers and teachers over syllabuses and teaching methods, novel schemes and improvements are constantly initiated locally. Moreover, because of a long tradition of opposition to the idea of educating children by, and for the State, political changes are not necessarily accompanied by educational changes. As Howson, Keitel and Kilpatrick (1981) point out: "changes in the curriculum often meant not so much a reshuffling of the academic content [...], but a widening in ideas of what constituted a curriculum" (p. 31). Thus, the provision of in-service courses for teachers has aimed more to introduce teachers to new ideas about teaching than to new contents to be taught. It has therefore become an essential prerequisite of the educational system in England, and since the reorganisation of teacher training institutions in the 1970s has been seen as an essential part of their offerings (McNamara and Ross, 1982). Other valuable sources for in-service education of teachers have included Teachers' Centres, and LEA advisers. Occasionally, initiatives for provision of in-service education took place at the central level as well. For example, one important development concerning primary teachers' education in mathematics was that undertaken in 1959, when one of the members of HM Inspectorate was seconded to the task of organising course and conferences all over the country (Moon, 1986).

A journey into the past of mathematics education in England and Portugal

Before the 'new maths'

One starting point for this journey into the past of mathematics education could well be the beginning of the 1960s, the period that immediately followed the international 'Royaumont' conference which "pleaded for a revolution in mathematics education" (Moon, 1986, p. 57). Yet to leave completely aside events pre-1960 would be unfortunate, as it would not illuminate the striking differences between England and Portugal with regard to the importance given to mathematics education matters. For example, it may be worth mentioning that in England, as early as 1871 the *Association for the Improvement of Geometrical Teaching* was created, and in 1894 this association published the first number of the *Mathematical Gazette*, a journal addressing mathematical teaching issues (Howson, Keitel and Kilpatrick, 1981). Another important contribution to mathematics education in England was the formation in 1911 of the *Association of Teachers of Mathematics for the South-Eastern Part of England* (Howson, 1982). This association aimed at facilitating "interchange of opinions and experiences among teachers of Mathematics, including Arithmetic, in schools of every type" (cited in Howson, 1982, p. 156).

As far as I can ascertain, the history of mathematics education in Portugal has not been written yet. This fact makes it difficult to be rigorous, but it seems that it was not before 1940 that the first mathematical association was formed (*Sociedade Portuguesa de Matemática*) and that a

journal (*Gazeta da Matemática*) related to mathematics and its teaching commenced its publication (Matos, 1986). It may be interesting to note, too, that the *Sociedade Portuguesa de Matemática* through its pedagogic committee was exclusively concerned with the teaching mathematics at secondary level.

The interest in primary mathematics education in England became even more apparent in 1938 with the forming of a subcommittee 'to consider the teaching of mathematics to children under eleven' (cited in Howson, 1982, p. 194), and afterwards with the publication of a report about 'the Teaching of Mathematics in Primary Schools' and the establishment of a new association of teachers of mathematics which appealed to many of those concerned with primary mathematics (Howson, 1982). In Portugal, the post second world war period was one of even more stagnation than before. In fact, some of the University lecturers, usual contributors to the *Gazeta da Matemática* were forced to resign their posts and even to abandon the country, and the publication of the journal and of papers related to the teaching of mathematics were hampered by that.

A further idea of the relative importance attributed to mathematics education in both countries is illustrated by the research in the field. Howson (1982) traces back more than one hundred years the origin of the educational research in mathematics education. It started with the publication of some papers on problems of errors of marking in the *Journal of Royal Statistical Society*. Dissertations and higher degrees in mathematics education started to be awarded in the 1920s. In his chronology of mathematics teaching in Portugal, Matos (1986) indicated that the first papers in the field of mathematics education were published in the *Gazeta da Matemática* in 1946. They dealt with the analysis of examinations results. In turn, higher degrees in mathematics education started no earlier than the mid-1980s.

After the 'new maths'

With the background just described, it is not surprising to find that Portugal was one of the few countries in Europe that was not present at the Royamount Conference in 1959, having sent simply a report to that meeting (Matos, 1986). Interestingly, the reforms which occurred quickly in most of Europe after the Royamount Conference (Moon, 1986) moved fast to Portugal as well. One may speculate that the formalist flavour of the 'new maths' was in tune with academic taste of the mathematicians in the Universities. The reforms in Portugal included the introduction of 'new maths' on a pilot basis in the two latter grades of the '*liceus*' in 1963. Four years later, the 'new maths' spanned all grades of the '*liceus*'. In 1971, the movement was extended to the '*escolas comerciais*', and '*escola industriais*'. In referring to the new programmes of these schools, Matos (1986) points out: "flowing from the French influence and that of Papy, the modern mathematics is presented as a new very precise language, based

upon logic, set theory, and structures. [...] Mathematics is presented completely removed from its applications. Geometry is limited to the study of the geometrical transformations. Functions are transformed as a particular case of binary relationships. The addition of integers is introduced through operations with vectors" (pp. 39-40). The 'new maths' movement was also spread with vigour to the *'escolas preparatórias'*. Moreover, as happened in other countries (e.g. France and West Germany), in order to attract the interest of parents and public at large a series of 'new maths' television programmes was presented by a prominent University professor (Matos, 1986). In the primary school curriculum, however, the first signs of 'new maths' only occurred in 1974. It is a significantly late date and highlights the contrast between the low level of importance attributed to primary education relative to other sectors.

One further factor which strongly influenced the state of primary education in general, and primary mathematics education, in particular, in Portugal in the mid and late 1970s is the ideology and 'democratic values' associated with the political revolution in 1974. In 1975, a new national curriculum for primary schools was launched. In the field of mathematics, the major sign of 'modernity' of the programme was evidenced by the inclusion of 'sets', and by the almost total exclusion of geometry. There was an obvious conflict between the general 'democratic' flavour of the curriculum pointing to the rejection of authoritarian teaching and the need for centring teaching in pupils' needs and experiences, on the one hand, and on the other, the use of a relatively formal and rigorous language derived from the 'new-maths' movement.

In England, in spite of a tradition of highly decentralised curriculum changes, the 'new maths' movement also had an impact all over the country. It gave rise to a secondary school reform project in 1961 (SMP), and almost in parallel to a primary mathematics curriculum reform in 1964 (the Nuffield Foundation project). These developments, however, never had the same kind of characteristics as in other countries. The formalism and rigidity of the 'new maths' were tempered by the British post-war tradition of emphasising teaching methods that aim at total development of pupils rather than only providing them with a body of knowledge. Another reason for the weak emphasis on the formal aspects of the mathematics was that of involvement of teachers (rather than mathematicians) in curriculum development projects. That the Nuffield project, for example, had comparatively little of the formal 'new maths' flavour can be inferred from the first formulation of its aims: "this will be designed to help them [children from 5 to 13] connect together many aspects of the world around them, to introduce them gradually to the processes of abstract thinking, and to foster in them a critical, logical, but also creative, turn of mind" (cited in Moon, 1986, p. 134).

Whatever was brought by the 'new maths' movement to England was soon to become a matter of great controversy. The 'new' primary mathematics, in particular, was submitted to public

criticism for not providing pupils with the needed numeracy and computational skills. Following the Plowden Report in 1967 that advocated 'progressive' approaches in primary schools, the Black Papers and other voices in the early 1970s were to denigrate the state of primary education (Moon, 1986).

It is against this mixture of 'centralised' tendencies with initiatives at local level and of climate of controversy that the developments of primary mathematics education had to be analysed in the late 1970s. In spite of the diversity, it was still possible to find common mathematical topics taught in English primary schools during those years. According to a survey carried out by HM Inspectors of Schools, these included the standard elements of arithmetic, geometry and measurement, as well as number patterns, estimation, practical applications and forms of visual representations (DES, 1978).

Primary mathematics education in the 1980s in England and Portugal

The decade of the 1980s represented a significant point of departure for changing primary mathematics education in both England and Portugal. In England, the decade was marked by the influence of three major reports: *Mathematics 5-11* (DES, 1979), *Mathematics Counts* (Cockcroft, 1982), and *Mathematics from 5 to 16* (DES, 1985). Of these three reports, *Mathematics Counts* was undoubtedly the one which was most influential. This report, the result of an enquiry over all the country about the state of mathematics education launched in the late 1970s, places great emphasis on the need to provide a wide range of mathematical activities which would cater for the development of children's computational, as well as logical, aesthetic and linguistic skills. Another important feature of the report is the endorsement of the use of calculators and computers in mathematics throughout the different years of schooling.

The introduction of microcomputers in English primary schools in the early 1980s constituted, in fact, another major evolution in the field of primary mathematics education in this country. In particular, it gave origin to the development of a great variety of software appropriate for mathematics lessons. As noted by Hughes (1987), most of the early programs were for the practice of skills, in many cases adding very little to the kind of mathematical experiences to which pupils were accustomed. Over the years, however, a diversity of software packages which allegedly lead to problem solving and to investigation have been developed. In particular, several versions of the Logo programming language have become widely available. Concomitantly, the implementation of computers in schools has been at the heart of much discussion and research in mathematics education that have taken place in the country during the 1980s. Such developments could have resulted in a major contribution to changing the state

of mathematics teaching/learning in the country, but for varied reasons this might not have been the case. Hughes (1987), for example, suggests that whereas in some schools the use of computers has already affected the kind of mathematics that takes place in the classrooms, in many other schools computers have been far from producing any real impact. A critical problem in using the computer in schools is, obviously, its limited availability. According to a recent survey of microcomputers use (DES, 1987), there were on average, 1.7 micros per primary school.

In Portugal, the 'new' political order of the beginning of the 1980s gave way to the launching of a new national curriculum for primary schools. The 'new' mathematics syllabus was practically confined to the standard topics: (1) sets, (2) space awareness and elements of geometry, (3) numbers and systems of numeration, (4) length, (5) area, (6) volume, (7) time and order, (8) weight; and (9) money. The way in which the programme is presented suggests that it follows a traditional form of hierarchical and compartmentalised knowledge. In comparing this programme with that launched in 1975, it is worth noting that in a period of five years the Portuguese official viewpoint had moved from an almost total absence of the study of geometry to the realisation that it is very important for the overall development of children. An implied criticism of the 1980 curriculum can be found in a statement of the document *Análise da Situação dos Programas* (Soares *et al.*, 1986): "The focus of the current mathematics programme is on children's intellectual development forgetting, namely, the affective, social, physical and aesthetic aspects" (p. 127).

Other more influential bases for the development of mathematics in Portuguese primary schools were brought by the 1980s. For example, an Association of Teachers of Mathematics was created, and the first journal exclusively devoted to mathematics and computers in educational matters was published. Moreover, post-graduate courses in the teaching of mathematics were offered for the first time and several individual research projects in the field of mathematics education were undertaken (Matos, 1986). At the level of the training of teachers, the recently created *ESEs* initiated their conjoint programmes for the training of teachers for *escolas primárias* and *preparatórias*, as well as offered in-service training courses for teachers. The fact that these new institutions have among their staff members lecturers in mathematics education who had recently been awarded a higher degree in mathematics education suggests that these institutions have the capacity to keep future and experienced teachers in touch with the changing needs of mathematics teaching.

In addition, a committee was formed in order to rethink the mathematics curriculum for all the school grades. It is especially significant that the programme for primary mathematics was considered as an integral part of the whole school mathematics curriculum and that the

committee was constituted by teachers rather than exclusively by University mathematicians. Finally, the country accompanied the international movement towards the use of computers in schools. In 1985, a national project (MINERVA) to implement computers in Portuguese schools was launched with the support of the Universities (Matos, 1986). Like in England, the introduction of computers in schools has given birth to a considerable amount of research related to mathematics education (e.g. Moreira, 1986; Ponte, 1990; Serrazina and Monteiro, 1990).

This background of great developments during the early and mid-1980s in England and Portugal has to be kept in mind, but they are probably too recent to have strongly influenced what is going on in primary mathematics lessons. Thus, in England, while primary mathematics has undoubtedly been greatly influenced by 'progressive' ideas (see, for example, Desforges and Cockburn, 1987), there is still evidence that mathematics lessons in many cases have a 'traditional' flavour (Lunn, 1984). In Portugal, the few studies available are not comprehensive enough to provide an idea of the state of primary mathematics lessons in the country. In referring to the state of schooling in general, Nóvoa (1987) points out that "the great majority of the Portuguese teachers had lost the effectiveness of traditional pedagogic practices without having had the means to build a new pedagogic strategy" (p. 779).

An additional source of information about primary mathematics in both countries is offered by textbooks, workcards, and other materials that teachers have at their disposal. Although it is beyond the scope of the present study to make a analysis of these resources, it is clear that the amount and variety of resources on which teachers can rely to nurture children's mathematical learning is much greater in England than in Portugal. For example, in England, it is possible to find a textbook full of pages of sums and another, for the same age group, full of pictures and open-ended questions. In Portugal, textbooks subsume the principles centrally determined and are all similar in format, falling somewhere between those two extremes. Moreover, written materials for Portuguese teachers are practically confined to the children's textbooks. This is in marked contrast with what happens in England where written materials for teachers include teachers' books, resources books, journals, as well as general education textbooks and documents on policy (Goodwin, 1987). In addition, English teachers can draw upon a variety of apparatus during their mathematics lessons (although they might vary from school to school since the decisions about resources are left to individual schools). Again, the contrast with what happens in Portugal. Classroom apparatus in the Portuguese primary schools is very limited, and in most cases, confined to the standard geometric sets with which schools were provided when they were created.

Looking at the large pictures such as these of the contexts of primary mathematics education in England and Portugal, I will restate in concluding this chapter the words I borrowed from the poet: *Times change with seasons, men too change their mind. We change the way we are, the way we feel...*

SUMMARY

This chapter has presented an introduction and background to the study. I have elaborated upon the claim that it is necessary to begin the task of rethinking mathematics education and that a strategy for doing so is to have teachers examine and possibly expand their attitudes towards mathematics and mathematics teaching. It was suggested that the computer and in particular the Logo programming language could be used as a starting point to help teachers to explore the nature of their beliefs about mathematics and mathematics teaching and reflect upon their practices. To this end, the stance taken was that of investigating how teachers' attitudes influence and are influenced by their participation in an in-service Logo-based mathematics course, and the analytical framework used was that of a cross-country perspective.

The point of a comparative perspective is that there may be aspects of the culture that impinge on teachers' attitudes towards mathematics and mathematics teaching, and that these attitudes are better understood by providing an international setting. The chapter ended with an examination of the two broad contexts that surrounded the study. It has provided salient features of the educational systems, training of teachers, and state of mathematics education both in England and Portugal. Although it was not exhaustive, the discussion has shown that the two contexts offer sufficient variation to make the use of a comparative perspective worthwhile.

CHAPTER 2

Different minds, different perspectives

(Review of literature)

This chapter presents a review of literature of empirical and theoretical research related to the area of enquiry. This thesis is concerned with the study of teachers' attitudes towards mathematics and mathematics teaching, and how these attitudes influence and are influenced by their participation in Logo-based mathematical in-service course. I would like to suggest that attempts to produce adequate descriptions and understanding of teachers' attitudes and attitude change in the context of an in-service programme benefits from the use of theories and models from disciplines other than mathematics education, such as social psychology and curriculum development. Therefore, before presenting a survey of literature closely related to the specific topics under investigation, I provide the reader with more general information about those issues that will serve as a useful and necessary background for the subsequent discussion and analysis.

Thus, the chapter is divided into four main sections. The first section is organised in terms of the key construct that is investigated -- attitudes. It addresses three major issues related to the construct linked to the purposes of this study: conceptualisation and definition of attitudes, attitude change, and attitude measurement. The second section examines the concept of staff development, and considers analyses that educational researchers have undertaken in order to make staff development effective. The section places the teacher at the centre of staff development efforts, yet without rejecting other factors equally or even more important than the teacher. The third section focuses upon studies of teachers' attitudes towards mathematics and mathematics teaching. These have two major aspects to them: factors influencing teachers' attitudes, and influences of teachers' attitudes upon their practices and pupils' outcomes. Finally, the fourth section provides an overview of research involving teachers' learning and teaching experiences with Logo and discusses the potential of a Logo-based environment to influence their attitudes towards mathematics and its teaching. At the end of each main section, there is an overall summary of the main points brought about by the discussion and analysis of the issues dealt with.

Having outlined this general framework, let me say a couple of words about the title I chose for the chapter. As I was undertaking the literature survey, the words of the Portuguese proverb *cada cabeça sua sentença* (which I came to translate into English as *different minds, different sentences*) came to mind. I echo with Bauersfeld (1988) that in education "there is no accumulative growth of understanding, because in the human sciences 'truth' is by nature human truth" (p. 41). But I want to suggest that a critical problem in educational research is that many researchers tend to treat educational reality, which is terribly complex, as if it were simple. I am not addressing here issues of a methodological nature. These will be discussed in the next chapter. The point here is of a theoretical nature. As Bauersfeld put it "we never escape from the Hermeneutic Circle or from the need for theoretical orientation" (p. 42). No wonder, therefore, that so many examples of conflicting results abound, as opposed to emerging competing theories. These, I want to believe, might exist in researchers' minds. From this vantage point I preferred to title this chapter as *Different minds, different perspectives*.

PERSPECTIVES ON ATTITUDES AND ATTITUDE CHANGE

During the last decade or so, there has been a growing interest in research on teachers' teachers' beliefs and theories (for a review of recent research see, for example, Clark and Peterson, 1986). These include among other things their conceptions of the subject matter teachers have to teach, their perspectives of their roles as teachers, and their attributions for the causes of pupils' performance. Within the mathematics education community, too, there has been an increasing awareness of the importance of studying teachers' beliefs about mathematics and mathematics teaching. For example, in a recent published research agenda of mathematics education, Cooney, Grows and Jones (1988) identified teachers' beliefs as one of the priority areas: "We must look at attitudes, beliefs, and knowledge. We must look for ways to try to work this into teacher education" (p. 257). But what are attitudes and beliefs? What follows is a discussion of this topic.

Conceptualising attitudes

As Eiser (1986) put it "we all have a rough idea of what attitudes are" (p. 11). Yet there has been little agreement among social psychologists, for whom people's attitudes are one of the main foci of study, about the meaning of the term *attitude*. This has been used in a variety of ways and different words have been used to represent the same construct. It may be worth getting a flavour of the controversy that has surrounded the topic.

Some social psychologists have proposed conceptualisations that associate attitudes only with affect. For example, Thurstone (1967) defined attitude as "the affect for or against a psychological object", and this definition seemed to have been widely accepted. For example, Fischbein and Ajzen (1975) state that "there is widespread agreement that affect is the most essential part of the attitude concept" (p. 11). Another common and influential definition of attitudes is that of a tripartite model proposed by Rosenberg and Hovland (1960): "we here indicate that attitudes are predispositions to respond to some class of stimuli with certain classes of responses and designate the three major types of responses as cognitive, affective, and behavioural" (cited in Pratkanis and Greenwald, 1989, p. 247).

While this latter conception has been the most widely accepted, it has been criticised on at least two grounds. One has to do with what the study of attitudes is for. It can be epitomised by the following question: "If attitudes include a behavioural component and therefore cannot be used to predict behaviour, why is it important to study them?" The other criticism is related to the apparent redundancy of the three components (McGuire, 1989).

In response to this kind of criticisms, other conceptualisations of attitudes have been proposed. For example, as recently as 1989, Pratkanis and Greenwald developed a socio-cognitive model of attitudes. According to this model attitudes have a cognitive representation (as opposed to a tripartite structure), consisting of "(1) an object label and procedures for applying that label, (2) a summary evaluation of that object, and (3) a knowledge structure supporting that evaluation" (p. 273). From Pratkanis and Greenwald's (1989) viewpoint, attitudes are not poor predictors of behaviour, but related to it in a complex way. For instance, they suggest that "people are more likely to act according to their attitudes when these are important for their self-concepts" (p. 272).

The previous discussion is suggestive of the sort of issues that have been at the heart of the attitude theory and research, namely the problem of attitude structure and that of the relationship between attitude and behaviour. To complicate the matters further, there has been little consensus as to what distinguish the concept *attitude* and other related concepts such as *beliefs*, *values* and *opinions*. Of course, it is not my intent to provide a detailed discussion of this issue. One or two illustrations will suffice. For example, Roacheach (1968) defined attitude as a "a relatively enduring organisation of beliefs that describe, evaluate and advocate action with respect to an object or situation around an object or situation, with each belief having cognitive, affective, and behavioural components" (p. 132). As it stands, there seems to be no great difference between Roacheach's tripartite conception of belief and the mentioned above Rosenberg and Hovland's tripartite model of attitude. A different conceptualisation of belief is

given by Fishbein and Ajzen (1975). For these latter authors, beliefs are "the information the person has about the object" (p. 12).

At this point, it might be worth noting that mathematical educators have also entered a similar debate about the meaning of *attitudes* and related terms. For example, Hart (1989) considers attitude toward an object as including "emotional reactions to the object, behaviour toward the object, and beliefs about the object" (p. 44), thus advocating a perspective close to the one provided by Rosenberg and Hovland (1960). In turn, McLeod (1989) along similar lines to Fishbein and Ajzen (1975) prefers to reserve the term *attitude* for "affective responses that involve positive or negative feelings of moderate intensity and reasonable stability" (p. 249) and consider beliefs and emotional reactions as separate constructs. He further distinguishes the terms *beliefs*, *attitudes* and *emotions* in terms of the degree of affective involvement, cognitive involvement, intensity and stability. Thus, beliefs are mainly cognitive in nature, whereas emotions are affective reactions that involve some physiological arousal.

In light of this murky background, I prefer to go along with those social psychologists that use the term *attitudes* in a broad sense and avoid distinguishing between attitudes and terms such as *cognitions*, *values*, *thoughts*, *beliefs*, and *opinions*. One of authors who has adopted such a perspective is McGuire (1989). He defines attitudes as "covert acts that project some topic of meaning to a position on some dimension of judgement" (p. 39). However, in defining attitudes in this way, that is, treating attitudes as a global concept, McGuire does not provide any clarity for the topic at least in a first encounter with this conceptualisation. If the use of a definition is to provide a particular set of information about a given topic, then a first approximation of conceptualising attitude may better take the form of Petty and Cacioppo's (1986) definition. Attitudes are:

general evaluations people hold in regard to themselves, other people, objects, and issues. These general evaluations can be based on a variety of behavioural, affective, and cognitive experiences, and are capable of influencing or guiding behavioural, affective, and cognitive processes. (p. 127)

Having this definition as a starting point, I would like to identify a range of issues and levels which can be found in the main body of work dealing with mathematics and mathematics teaching, and then conceptualise attitudes in light of both the starting point definition and emerging issues.

Attitude change

As might be expected, the variables that have been suggested as influencing people's attitudes and attitude change are many and diverse. Social psychologists' efforts to illuminate the

processes involved in attitude formation and change have resulted in a certain number of theories providing a plausible account for these phenomena. No common agreement exists, however, as to which factors are most salient and at which developmental level. This subsection offers elements of a paradigm of attitude change, called the "Elaboration Likelihood Model" (ELM; Petty and Cacioppo, 1986), one that reflects current research assumptions and tendencies. In my opinion, it provides particularly useful material upon which the present study of teachers' attitude change can be built. Before turning to the consideration of the ELM model, it may be instructive to document briefly the existence and content of alternative theories.

Attitude formation and change

As Halloran (1967) suggests the problem of attitude change cannot be discussed without acknowledging the issue of attitude formation: The two "processes are interwoven and continuous. All the time as part of our social development we are adopting new attitudes, modifying and relinquishing old ones" (p. 60). Although the two processes cannot be cleanly distinguished, he goes, as a matter of simplification, to discuss them separately. In reviewing work of some theorists in the field, Halloran (1967) notes that attitudes are learned and that there are three major sources from which attitudes are learned: (a) direct experience with objects and situations; (b) explicit and implicit learning from others; and (c) personality development. That is, both personal and social factors have a role to play in the formation of attitudes. More recently, McGuire (1985), in analysing empirical findings of several attitude researchers, has extended the set of attitude determinants to incorporate genetic factors as well.

These variables are likely not to be an unordered list of independent influences. Rather they may interact in a dynamic process that accounts for the continuous process of attitude formation and change. Kahle (1984) proposes a particularly interesting theory by applying general theoretical accounts of Piagetian theory to the social psychology of attitudes. Kahle's theory links attitude formation and change to major concepts: adaptation and equilibration. According to Kahle, attitudes are seen primarily as a means of adaptation to one's environment. Changes in attitudes occur continually "through assimilation, accommodation, and organisation as new information is obtained and old information is enhanced or clarified" (p. 41). An important consideration is that "a trait or attitude that is adaptive in one situation may not be at all adaptive in another situation" (Kahle, 1984, p. 39). That is, people's attitudes toward an object takes on different meanings according to the context in which they are situated.

Attitude change as a result of persuasive communication

A second perspective on attitude change is related to attempts to influencing attitudes and behaviour via persuasive communication. Oversimplifying, work on attitude change within this perspective has been devoted to studying the effects on people's attitudes of three kinds of

factors: (1) source of communication variables (e.g. expertise, status); (2) message attributes (e.g. style, order of the content); and (3) audience characteristics (e.g. cognitive needs and styles, susceptibility to persuasion). In examining the problem of attitude change here, my main concern will be with the process of how individuals respond to a given message by a given source.

Despite the diversity of theories that have tried to explain how a message is interpreted by those for whom it is provided, there are some points with which social psychologists would probably agree. The following ideas extracted from a summary by Halloran (1967) in reviewing different perspectives seems to be useful to restate here (in spite of the fact that it was offered more than twenty years ago):

- It is possible to change attitudes.
- In order to produce change a suggestion for change must be received and accepted.
- Reception and acceptance are more likely to occur where the suggestion meets existing personality needs or drives.
- The suggestion is more likely to be accepted if (a) it is in harmony with valued group norms and loyalties; and (b) the source of the message is perceived as trustworthy or expert.
- Change in attitude is more likely to occur if the suggestion is accompanied by change in other factors underlying belief and attitude. (p. 59)

This summary hints at two major sets of variables within the individual that have been shown to affect attitude change: cognitive and motivational. The former is related to the extent to which the individual is able to receive the message, whereas the latter is assumed to determine whether or not he/she accepts either the message or the source. In explaining how change occurs, some authors have emphasised the role of cognitive variables, while other authors have focused on motivational ones. It is in the first category that one of the most well-known theories of attitude change is included -- Festinger's (1957) theory of cognitive dissonance (cited, for example, in Halloran, 1967). Again at risk of oversimplification, the main point of Festinger's theory is that "the existence of dissonance give rise to pressures to reduce the dissonance and to avoid increases in dissonance" (quoted in Halloran, 1967, p. 101). Thus, if one is presented with a message that is contrary to one's attitudes, there is a tendency to reduce the dissonance by changing those attitudes. An example of a theory included in the second category is Kelman's (1974) identification process of attitude change. According to this author, changes in attitudes may occur at different levels depending on the extent to which the individual accepts the external source. It may be that the individual complies with the source as he/she expects to gain rewards by adopting the message content. Alternatively, the adoption of

the message content may be based on the identification of the individual with the source, in order to keep or establish a satisfying personal relationship. Finally, it may happen that the message content is internalised by the receiver as it fits in his/her general value system.

In reviewing these and other authors' approaches to attitude change, McGuire (1985) stated that "each of these partial views yields valid predictions in some circumstances and misleads in others where the emphasised aspect is overridden by other facets of the person" (p. 295). A somewhat better balanced perspective which attempts to integrate both cognitive and motivational factors seems to be the already mentioned "Elaboration Likelihood Model" recently proposed by Petty and Cacioppo (1986).

The "Elaboration Likelihood Model"

The model postulates that "the amount and nature of issue-relevant elaboration in which people are willing or able to engage to evaluate a message vary with individual and situational factors" (Petty and Cacioppo, 1986, p. 128). By *elaboration*, Petty and Cacioppo mean the extent to which people think about the message arguments. The term *likelihood* refers to the importance that is attributed to mediating variables which motivate or enable the individual to engage in such elaboration.

According to the model, there are two routes to attitude change as a result of a persuasion message. One occurs when the individual is motivated to process the message (central route). The other route may occur as a result of a simple cue in the persuasion context (peripheral route). Petty and Cacioppo state that attitude change induced via the central route is more enduring than that induced via the peripheral route. In both cases, the individual is seen as an active participant in elaborating the message. But whereas the central route involves considerable thought about the message content, in the peripheral one the elaboration is low and simple decision rules are used in judging the message. Major variables yielding to the central route include motivational and cognitive factors residing within the individual (e.g. personal relevance; need for cognition; personal responsibility; initial attitude towards the message topic; prior knowledge about the message topic) and situational ones (e.g. message comprehensibility; repetition; match between the message content and the individual's value system). The authors suggest that the most important variable affecting elaboration of the message is personal relevance, that is, the extent to which advocacy of the message has significant consequences for the person's life. In turn, the variables yielding to peripheral routes to persuasion are mostly related to the message and source of the message (e.g. source credibility and attractiveness; number of arguments).

The basic assumptions of the ELM model are depicted in Figure 2.1. As the picture suggests, attitude change may occur even when the individual is not motivated, but in such a case it is relatively temporary and unpredictable of behaviour. It is also interesting to note that attitude change can occur either in the direction congruent with the message content (positive attitude change) or in the unintended direction (negative attitude change).

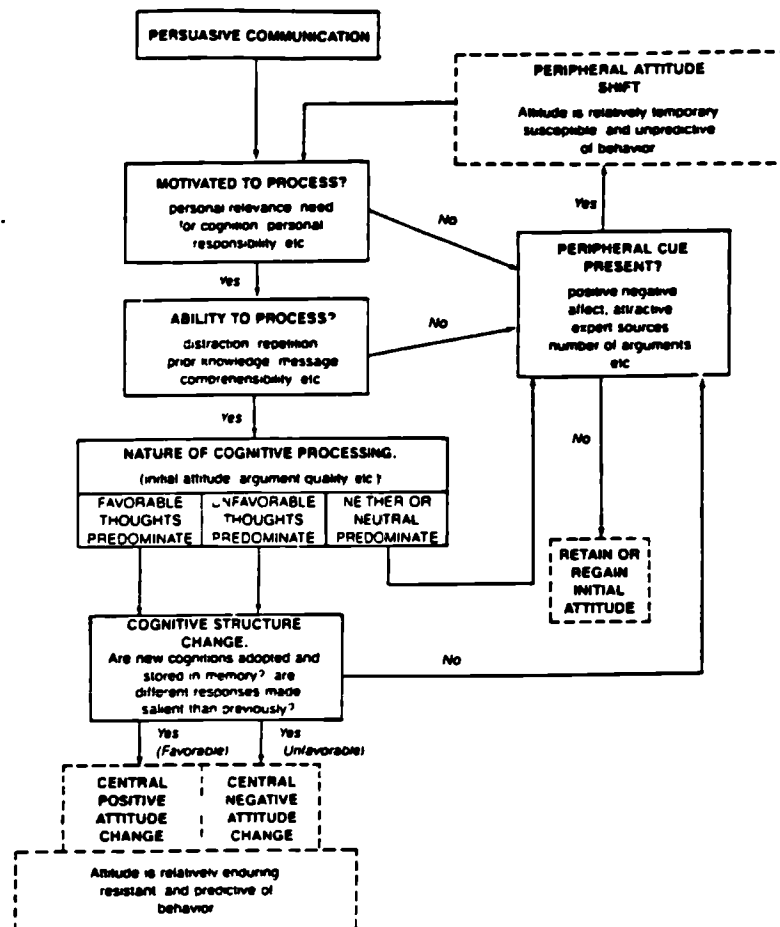


Fig. 2.1: The "Elaboration Likelihood Model"
Source: Petty and Cacioppo, 1986.

It goes without saying that Petty and Cacioppo's model is not without criticisms. The phenomenon of attitude change is rather complex to allow for a single model alone offering complete explanation. A major shortcoming of the Petty and Cacioppo's perspective resides in the fact that they seem to ignore the role of group processes in communication. According to Halloran (1967), these constitute a critical force in determining whether the individual changes or not. For example, it seems that in a group situation if the majority of the group is in favour of the communication an individual would be more influenced than if he/she is alone. In contrast, the individual would be less influenced by the message when the group is not favourable to the message. Halloran also pointed out the importance of reference groups or affiliation groups. In a similar vein, Walter and Marks (1981), in examining the different forces

to which an individual is subjected in an experiential learning situation, referred to fellow participants as *restraining* or *facilitating* change. For example, dominant participants may reduce the involvement of others, whereas enthusiastic members may spread their enthusiasm to others.

Attitude assessment

The literature in the field is rich with methods for assessing people's attitudes. However, the question of what are the best strategies or approaches to assess people's attitudes is an enormous one. As a forewarning to the problems in attempting to answer this question, the reader is advised to reflect on the many meanings of attitude which were reviewed in the first sub-section. Here, I wish to offer a sense of the main methods rather than a thorough review (for a thorough review see, for example, Fishbein and Ajzen, 1975), the purpose being that of learning their merits and shortcomings, as well as that of helping the reader to become acquainted with what follows in subsequent sections.

In somewhat oversimplified terms, the methods to assess people's attitudes may be grouped into three categories: (1) paper and pencil instruments such as attitude scales, relying on personal forms of intervention and based on the extent to which people agree with statements expressing a range of opinions about an object; (2) techniques such as clinical and anthropological observations, diverse types of interviews, and repertory grid techniques, which involve the intervention of the researcher over a period of time during which the person makes decisions on a continuous basis; and (3) methods derived from projective techniques whose objective is to have individuals express themselves freely when responding to a certain cue (a photograph, a word, a sentence or a story), and which in some cases attempt to conceal their real objectives.

Attitude scales are among the most common methods to assess people's attitudes. Although there are considerably different scaling procedures (e.g. Thurstone, Likert, Guttman, and Osgood), all of them have as basic objective to distribute people along a continuum representing their attitude towards an object. These methods have been extensively reviewed by several authors (e.g. Lemon, 1973; Fishbein and Ajzen, 1975) who have also pointed out their strengths and weaknesses. I will only provide here an abbreviated account of the Likert and Osgood methods: one of the reasons for this choice is that they are those most commonly found in the literature in mathematics education (e.g. Lumb and Child, 1976; Schofield, 1981; Lerman, 1986; Peterson, Fennema, Carpenter and Loef, 1989). In the Likert method, statements related to the attitude object are previously classified into favourable and unfavourable. Answers to favourable items are normally scored from 1 to 5, and in the reverse order for unfavourable items. The person's attitude score is obtained by summing across all

the items. The method developed by Osgood, labelled *semantic differential*, consists of pairs of adjectives which can be used to reflect individuals' feelings towards an object. People are asked to evaluate the attitude object in terms of each of the adjective pairs normally in a scale varying from -3 to +3. The sum of the different scales scores is taken as an index of the person's attitude towards the object.

Some researchers have attempted to investigate the comparability of those four methods. One of such studies was concerned with the relative merits of the Likert and Thurstone scales (Edwards and Kenney, 1967). The researchers concluded that the Likert method seems to lead to higher reliability with fewer items than the Thurstone one. They also pointed out that the Likert technique is less time consuming and laborious. Another study (Title and Hill, 1967, cited in Lemon, 1973) compared the effectiveness of the four methods in predicting behaviour and showed that the best prediction was achieved by the Likert scale.

Criticisms have been made of the attitude scales methodology on at least three grounds. Firstly, it has been argued that in answering verbal stimuli, respondents are generally aware that their attitudes are being assessed. They may, therefore, prefer either to give socially acceptable answers or avoid making their attitudes explicit. Secondly, it has been contended that in answering the verbal stimuli respondents are compelled to think about their attitudes. This process may well cause their attitudes to change. The third criticism is related to the stimuli themselves. These can include statements or words which are irrelevant to the attitude under investigation, whereas other more important matters may be left out. Another issue one may raise concerns about is the appropriateness of using scaling procedures which were developed when attitudes were defined exclusively in terms of an affective component, if one endorses a wider perspective of the concept. In this regard, it is worth noting that Fischbein and Ajzen (1975) point out that conventional scaling procedures can be used to assess intentions of behaviour as well. Less encouraging as to the use of scaling procedures is Ostrom's (1989) criticism concerning the cognitive aspect of attitudes: "in terms of cognitive system, there may well be no evaluative continuum" (p. 31). In the light of recent orientations to the study of attitudes that emphasise socio-cognitive approaches, Ostrom (1989) then takes on a critical standpoint as to the quantitative aspects of attitude assessment and maintains that researchers should "become more concerned about the *qualitative characteristics* of attitudes" (p. 33). Some advantages of the attitude scales approaches are that they are specific and clear, are useful for comparing people's attitudes, and without considerable extra work can be applied to a large number of individuals.

The forms of data gathering to infer people's attitudes included in the second category (clinical and anthropological observations, diverse types of interviews, and repertory grid techniques)

may constitute an alternative that answers some of the above criticisms. However, it goes without saying that these methods have drawbacks as well, the most obvious of which are the costs and complexities inherent in their application. These difficulties make them not suitable when one is interested in assessing the attitudes of a large number of people. In addition, clinical and anthropological observations may well be criticised in that they refer to what people do, and not to what people think and feel. Observations may nevertheless be useful to enlighten people's attitudes. In turn, interviews seem appropriate to assess what people think and feel, but there is, of course, a risk that people are not willing to say what they actually think and feel.

Of the methods included in this second category, repertory grid techniques seem to be especially appropriate to infer people's attitudes. These techniques are based on Kelly's Personal Construct Theory, which assumes that each individual makes sense of the world in different ways using their own 'personal constructs' in the form of bi-polar criteria. In order to elicit these constructs, individuals are presented with triads of elements and asked to point out ways two of the elements are similar, yet different from the third one. Descriptors used by the individuals constitute the pairs of bi-polar criteria which are then arranged to form the repertory grid (Lemon, 1973). In recent years, this method has been widely used in education as a means of allowing both learners and teachers to become aware of their 'personal constructs', thus contributing to making them conscious agents who are able to participate actively in the educational process. The major weakness (and possibly one of its strengths as well) of this method lies in its strong emphasis on the individual, thus making it difficult to compare attitudes among individuals. Another problem with the method resides in difficulties involved in its administration which may necessitate the work of a 'specialist'.

Finally, the methods included in the third category (based on projective techniques) may be especially useful in making explicit certain aspects of attitudes that remain invisible to the more structured techniques. As in the previous case, however, projective techniques are very time consuming. This makes them unsuitable for application in cases in which the researcher is interested in tapping the attitudes of a large number of individuals. There is also a difficulty in interpreting the respondents' reactions. Possibly as a result of this latter reason, they appear to have not been very widely used, at least in the field of mathematics education. Moreover, these methods can be criticised on the ground of ethics for their lack of clarity as to their actual purposes.

The above discussion has pointed to weaknesses and strengths of various methods, and has suggested that the state of the art is sufficiently primitive that it does not indicate the best approach to assess people's attitudes. Another important consideration emerging from the

previous sub-section is that people's attitudes are most likely to be influenced by the specific situation in which they find themselves. This consideration has at least two consequences. First, investigations of people's attitudes through different methods may yield distinct results. I would like to suggest that eventual distinct results may be better interpreted as different indicators of the same underlying attitude rather than as a sign of lack of consistency. Thus, any research agenda in this area must address this issue and will benefit from the use of more than one approach to assessing people's attitudes. Second, if attitudes towards an object are likely to be influenced by the situation, then methods of assessing attitudes in settings in which they naturally occur might be most appropriate. This is clearly at odds with approaches such as those relying on structured paper-and-pencil tests. The main disadvantage of a naturalistic orientation is, as already stated, that it is labour-intensive and thus very limited in the numbers of people whose attitude can be assessed.

Summary

The key construct used in this study in connection with teachers' thought processes with regard to mathematics and mathematics teaching was *attitude*. With this term I intended to bring together two (or three) sides of the same coin: what teachers think about mathematics and mathematics teaching, and what they feel about them (as well as what they do). The literature reviewed in this section has shown there are different conceptualisations of attitudes. In face of lack of striking evidence in favour of one these conceptualisations, it seems quite reasonable to adopt a wider perspective of attitude that deals conjointly with what people feel and think (and do). The point is that in addition to considering relevant what teachers think about mathematics, I do want to recognise teachers' feelings about the subject such as liking the subject and being confident in dealing with it, and their negatives, as equally important. The definition of attitude adopted as a starting point for the present study was that proposed by Petty and Cacioppo (1986).

Especially important for the context of the study is that the above definition is comprehensive in the sense that attitudes may focus on people, objects and issues. Moreover, according to such definition attitudes have the inherent property of being differentially manifested along a range of dimensions or constructs rather than a single one. The definition can therefore be useful in addressing a variety of situations related to mathematics and mathematics teaching. For example the expression "attitudes towards mathematics" may be used to refer not only to the degree of one's liking or disliking for mathematics, but also the confidence in one's ability to deal with mathematics, as well as what one thinks mathematics is about. In addition to the breadth of Petty and Cacioppo's definition, it is significant that these authors also propose a

model of attitude change which seems relatively straightforward to use in the context of investigation of teacher' change that is object of the present study.

The section has also examined different approaches for assessing people's attitudes. I will leave open, for the moment, the question of what approach I will ultimately use within this study. The use of different approaches, however, does seem desirable. The work reviewed in the section entitled "Teachers' attitudes towards mathematics and mathematics teaching" will provide further insights into what the most effective approaches to assess teachers' attitudes might be.

PERSPECTIVES ON IN-SERVICE EDUCATION FOR TEACHERS

In surveying the literature on educational change (which is not presented in this review due to space limitations), I became aware that in-service education was a necessary, but not sufficient, means for getting teachers to change. The purpose of this section is to provide an overview of available information from research about how conditions of in-service education effectiveness can be created. Further, the section will furnish essential knowledge about how teachers' characteristics may interact with the information provided by the in-service programmes.

In this section, the terms *in-service education and training* (INSET) and *staff development* are used interchangeably, to mean

those education and training activities engaged in by primary and secondary school teachers and head teachers, following their initial professional certification, and intended primarily or exclusively to improve their professional knowledge, skills and attitudes in order that they can educate children more effectively. (Bolam, 1986, p. 18)

What makes in-service effective?

The above question may be considered somewhat odd, as it may be argued that one cannot turn to in-service effectiveness issues without addressing its goals. Conditions required to promote cognition-related aims may be very different from those required by a programme which is mainly directed to affective aims. It may also be useful to distinguish between programmes according to the degree of complexity and familiarity of content and skills to be dealt with. However, I would like to take up the issue at a more generic level to illustrate the kinds of processes and conditions that one must attend to in order to achieve substantial teacher development. I would suggest that there are at least two types of focus reflected in the literature in the field: (1) components and methods of training; and (2) organisational matters. In what follows, a discussion centred around these two topics is presented.

Training methods and components

In analysing the literature on in-service training, Joyce and Showers (1980) identify five components which alone or in combination influence in-service effectiveness. In addition to the traditional presentation of theory and description of skills, these authors consider that staff development programmes are most efficient when they include: (a) modelling or demonstration of skills (e.g. through a film); (b) practice in simulated and classroom settings; (c) structured and open feedback (e.g. group discussions); and (d) coaching (assistance in the classroom for transfer of skills). Joyce and Showers (1984) state that coaching is particularly important when the training involves more than 'fine tuning' of skills. While this might be true, the coaching component may be seen as a problematic component as well. Accustomed to working in isolation, teachers may be reluctant to accept the presence of intruders in their classes. On the other hand, in cases in which the new proposed skills or approaches are in conflict with teachers' views and/or teachers are convinced that their own way of teaching is an effective one, it is likely that coaching will not be welcomed.

In investigating the effectiveness of Joyce and Showers 'coaching' component on teachers' adherence to practices recommended in in-service training, Sparks (1988) compared three groups of teachers all provided with the same kind of workshop sessions but with different experiences between the workshops. Two of the groups had coaching assistance which was provided in one case by the trainer and in the other by a peer. The third group had no extra support activities. Sparks found that the teachers in the group with coaching provided by a peer were those who showed more receptivity to the recommended practices. This finding may be interpreted as an indication that in terms of what works in practice, teachers are more likely to rely on and feel less threatened by the presence of those who share with them the same kinds of job and related concerns than that of an 'expert'. In a previous piece of work, Sparks (1983), in discussing the kinds of training activities that might contribute to teachers' professional development, brings together the components proposed by Joyce and Showers (1980), and an activity of 'diagnosing and prescribing' based on observation and analysis of teachers' own teaching behaviour. In doing so, Sparks (1983) recognises the importance of "building an awareness for the need to change before attempting change" (p. 67).

The idea that "few teachers can move from a staff development programme directly into the classroom and begin implementing a new programme or innovation with success" was also stressed by Guskey (1985, p. 59). Thus, he suggests that continued support and follow-up in the classroom should be readily available. One of the prime ideas of Guskey is that teachers are likely to respond favourably to a new programme or innovation when, and perhaps only when, they have evidence that it enhances pupils' learning outcomes. That is, according to this author "significant changes in teachers' beliefs and attitudes takes place only after student learning

outcomes have changed" (p. 58), rather than the other way around. Moreover, he points out the importance of offering teachers the opportunity to meet and share their experiences in an "atmosphere of collegiality".

Reflecting a similar point of view concerning the role of discussion, Sparks (1988) maintains that provisions to increase teachers' receptivity to new ideas should include opportunities for (a) discussing how new suggested practices differ from the old ones; (b) discussing the possible influence of the proposed strategies on pupils; and (c) sharing their positive and negative reactions to recommended practices. In addition, Sparks suggests that presentation of the theory and research underlying the proposed practice, as well as some form of testimonial by those teachers who have already used the new practices will be most helpful increase teachers' receptivity.

The issue of discussion is also brought to light by Pinner and Shuard (1985). In reviewing staff development programmes in primary mathematics in England during the period 1978-82, these researchers state that "good opportunities for discussion are regarded very highly by many course-goers" (p. 183). However, they also note that too much discussion may appear to course participants as a waste of time. They then suggest that the use of group activities in a somewhat less structured context than that provided by a group discussion may be equally influential in bringing about the sharing of ideas.

Organisational matters

Far less consensus than that found about the previous topic seems to exist with regard to in-service course organisational matters such as duration and scheduling. In a synthesis of research on staff development for effective teaching, Sparks (1983) states that one-shot programmes, even if they last two or three days, are largely non-effective. He further advocates in-service programmes consisting of four to six three-hour sessions spaced one or two weeks apart. Contrasting with this view is Wade's (1984/85) conclusion drawn from a meta-analysis of research on in-service education. In her report, she concludes that "there was no significant difference in the effect sizes of programmes lasting six months or less versus those lasting more than six months" (p. 50), nor between those lasting a few hours and those lasting more than 30 hours. These results are rather surprising, but may be, as Sparks (1984/85) suggests, that both the frequency and the number of hours per session matters more than the total number of hours of the in-service programmes.

By focusing almost exclusively upon the effects of in-service courses on teachers, both Wade and Sparks do not illuminate how the specific course organisational matters mediate the process of teacher development. Departing from this kind of methodological approach, Rudduck's

(1981) book *Making the Most of the Short In-service Course* attempts to examine how in-service courses are interpreted and acted upon as teachers participate in them. In particular, the author portrays three programmes which had similar purposes, but which inform different patterns of organisation. Among other things, Rudduck suggests that if the time in-between sessions is to be used to allow teachers to try something out, then sessions held once a fortnight rather than once a week may provide a better framework. That frequency of in-service course sessions can have significant pedagogic consequences was also emphasised by Ponte, Norman, Davis, Eshun and Jensen (1986). In evaluating an instructional computing in-service course for primary and middle school teachers which was run for two consecutive weeks, they concluded that "the course was not highly successful regarding the instructional value of pupils programming" (p. 384). As a consequence, Ponte *et al.* propose that future courses should be of a different format allowing for alternating course sessions with course assignments related to the development of sample pupil programming tasks. It can be argued, however, that long intervals in-between sessions may jeopardise teachers' interest in, and sense of ownership and control over what has been taught during the course sessions.

Amid this debate over organisational matters, there has also been little agreement over other aspects too. For example, as far as the location of in-service courses is concerned, some authors have argued in favour of in-school programmes, whereas others have considered attendance at outside in-service meetings a crucial aspect of teachers' professional life. Other debates have focused upon agents providing in-service (internal versus external), and on in-service users (individual teachers versus whole staff).

The teacher as learner

There is evidence that some teachers appear to become more involved in and profit more from a given in-service programme than others. Therefore, in addition to examining features of in-service programmes that make them 'effective', it is also important to concentrate on characteristics of the targets of in-service programmes which appear to have implications for participation success. Before that, let me present succinctly what seems to be an important perspective to take into account in designing such programmes -- *adult learning theory*.

Adult learning theory

As a definable movement, adult learning theory was nurtured in the mid 1970s by Knowles (1984) who came to label it as *andragogy* (as opposed to *pedagogy*). Having recognised "the unique characteristics of adults as learners and their learning processes" (p. 6), Knowles emphasises the need for a new approach to learning, the andragogical model, that takes into

account those characteristics. Stated briefly, the primary assumptions of the andragogical model are as follows:

- adult learners need to be perceived and treated by others as being responsible for their own learning (self-directed);
- adult learners enter into an educational activity with a wide range of experiences which should be used as a resource for learning;
- adults become ready to learn when they experience a need to know or do something in order to perform more effectively in some aspect of their lives; and
- learning experiences should be organised around life situations rather than according to subject matter units.

Scattered throughout *Andragogy in Action* (Knowles and associates, 1984) are examples of the ways in which different groups of adults have engaged in learning activities. Interestingly, none of the examples presented concern teachers involved in staff development programmes. A major review of adult learning theory and its implications for in-service training of teachers is provided by Corrigan (1986). In synthesising the work of different authors, he points out some major conclusions for INSET. These include:

- there is a need to provide a variety of resources, field experiences instructional materials and learning alternatives which take into account the diversity of teachers to be served;
- preference should be given for experience based in-service in which reflection upon practice is the key process characteristic;
- the role of the adult educator should be that of a colleague, consultant and adviser, as well subject matter specialist and researcher; and
- in-service education is virtually useless if the objectives of training programmes are not valued and rewarded by the power structure of the school system.

In short, a model of a staff development programme is proposed which involves the creation of an atmosphere of collegiality between the course instructor and the teachers participants, and among the participants themselves. Moreover, passive, transmission of information based methods should be minimised, in favour of active, experiential (Walter and Marks, 1981) approaches to learning.

The proposed model, however, is not without risks. For example, as Knowles (1984) notes, given a tradition of a pedagogical model of teaching in formal education, adults who come to a formal learning situation may expect to be taught through a delivery content approach, and get

disappointed and even resentful when meeting a different one. This is illustrated, for example, by the account of Holly and Martin (1987). In evaluating an INSET initiative involving secondary teachers in England, and which was based upon an active, experiential, participative approach, these authors recall some of the teachers' voiced conflicts of the kind: "I want someone to teach me didactically how to teach non-didactically". It is quite reasonable to assume that the andragogical approach requires extra effort of teachers, and that some may not be willing or prepared to undertake such exercise. The idea that teachers' personal characteristics can affect the extent to which they benefit from their participation in in-service courses, and in particular from programmes using an experiential approach gains further support from Holly and Martin's (1987) assessment: "much of TRIST will have 'felt' experiential to the participants, too much so to some; alternatively, some of the TRIST will have felt not experiential enough" (p. 189).

Teacher characteristics and participation in INSET

As already suggested, there is evidence to support the idea that the same staff development programme may result in different learning experiences for different participating teachers. The empirical literature on INSET indicates that there are six major variables that appear to account for these differences are: (1) length of teaching experience; (2) teachers' educational philosophies; (3) sense of efficacy (Ashton, 1984); (4) motivation for joining the in-service programme; (5) attitudes towards the object of the programme; and (6) number of in-service programmes attended. What follows illustrates the importance of some of these variables as evidenced by research findings.

Pinner and Shuard (1985) in monitoring in-service education in primary mathematics in England, identify four main stages of teachers' professional development: initiation, consolidation, integration and reflection. According to these authors, at each of the stages teachers have different ideas, concerns and needs about mathematics education, thus requiring different types of help provided by in-service courses. For example, for a teacher at the initiation stage a single session INSET course of the type that give 'instant' ideas on a topic may be very useful, while a teacher who has attained the reflection stage is more likely to profit from a long course which provides him/her with time for reading, discussion and study. However, this may not apply to cases in which teachers face situation of novelty, such as when new content is taught or they take on a new role. In such cases, Pinner and Shuard suggest that teachers may go back to the initiation stage, although their passage through this stage may be influenced by past experiences.

Empirical evidence of the influence of teachers' educational philosophies on their reactions to staff development programmes is provided, for example, by Holt and Johnston's (1989) study

of two teachers participating in a Masters of Education programme. These two teachers were close in age and had somewhat similar number of years of teaching experience (eight and thirteen years). One of the teachers endorsed views similar to those underlying the Masters' programme, whereas the other teacher's educational philosophy differed from that of the course. Holt and Johnston suggest that the differences in philosophy played a major role in determining their reactions to the course. Along similar lines, Duffy and Roehler (1986) identified four sets of filters through which teachers sieve new information: conceptual understanding of curricular content, concept of instruction, perception of the demands of their working environment, and their desire for achieving a smoothly flowing school day.

Holt and Johnston's (1989) research also suggests another cause that might account for the two teachers' different reactions to the Masters' course: the extent to which they felt secure about their current classroom practices, and therefore the extent to which they felt motivated to change. This brings me to the next set of distinct but related variables which are likely to affect teachers' participation in staff development programmes: sense of efficacy and motivation to attend them. Ashton (1984) defines teachers' sense of efficacy as "the extent to which teachers believe that they have the capacity to affect student performance" (p. 28). The importance of teachers' sense of efficacy is revealed, for example, in Sparks' (1988) study which investigated relationships between teachers' characteristics and attitudes towards practices recommended in an in-service course.

Summary

The above discussion illustrates how literature and research on staff development call attention to particular aspects that appear to be associated with the effectiveness of in-service programmes. However, it is clear that each staff development programme will have its own issues, its own obstacles and tensions, and therefore the planning of an in-service course should be seen in the light of various contextual dimensions pertaining to that particular programme.

Nevertheless, at least two general important ideas can be learned from the literature reviewed. First, the dominant concern of in-service as related to the use of new ideas or practices should be less with offering a 'recipe' and more with providing teachers with opportunities for both 'doing' and 'thinking'. In particular, the idea of considering teachers as responsible professionals able to engage in 'critical reflection' gains weight and may be "the basis for -- the *sine qua non* of -- educational innovation and change" (Kemmis, 1987, p. 74).

Second, because teachers conceive their work in very different ways and approach staff development programmes with different motivations, the content and structure of programmes need to be framed taking into account this diversity. As Sparks (1983) put it "just as some

methods work best with some pupils and not others, staff development programmes may need to be adapted to fit various teacher characteristics and attitudes" (p. 70). Moreover, it is quite reasonable to expect that this diversity mediates what teachers get out from the information provided in a staff development programme and therefore the effects that this can have on them.

TEACHERS' ATTITUDES TOWARDS MATHEMATICS AND ITS TEACHING

This section reviews empirical literature related to teachers' attitudes towards mathematics and towards mathematics teaching. It attempts to illustrate the work that has been undertaken in this area by describing a wide variety of conceptual orientations, methodological approaches, and findings of research studies of teachers' attitudes towards mathematics and mathematics teaching. Given the scarcity of research concerning primary teachers' attitudes towards mathematics and its teaching, the literature survey includes not only studies involving primary teachers but also concerning secondary mathematics teachers, at both pre- and in-service level.

The literature reviewed in this section addresses two main issues. The first seeks to justify the importance of studying teachers' attitudes towards mathematics and its teaching in terms of their relationship with both teachers' instructional practices and pupils' mathematical outcomes. The second concerns the problem of exploring factors that might account for teachers' attitudes towards mathematics and its teaching, and in particular examining the influence of mathematics programmes on teachers' attitudes.

The effects of teachers' attitudes towards mathematics and mathematics teaching

It has been generally assumed that teachers' attitudes towards mathematics and mathematics teaching might affect their instructional practices, as well as their pupils' achievement in and attitudes towards the subject. This apparently simple statement has resulted into a considerable number of research studies which have been far from producing conclusive findings. For example, Begle (1979) in analysing several studies concerning mathematics teachers' effectiveness in the U.S., concluded: "the effects of a teacher's subject knowledge and attitude on student learning seems to be far less powerful than most of us had realised" (p. 54). In addition, Begle contended that "attempts to improve mathematics education would not profit from further studies of teachers and their characteristics" (p. 55).

It is interesting to note that Begle's contention followed a similar trend by social psychologists. They had questioned the usefulness of studying people's attitudes on the grounds that there was no relationship between one's attitudes and behaviour. The restoring of interest in the study of people's attitudes focusing on their structure rather than on their measurement, the emerging of new lines of educational research emphasising the use of ethnographic methodologies, the recognition of the importance of research on teaching and in particular on teachers' thought processes have changed the state of the art in the middle and late 1980s. Considerable progress has recently been made about the effects of teachers' attitudes towards mathematics and mathematics teaching both on teachers' instructional practices and pupils' mathematical outcomes. The purpose of this sub-section is to summarise the main lines of enquiry around these two themes.

Influence on pupils' mathematical outcomes

What follows is a summary description of three post-Begle (1979) studies which aimed at investigating the possible effects of teachers on pupils' mathematical outcomes. These studies, which made use of different methodologies and were based upon distinct theoretical orientations, appear to contradict the above-mentioned opinions of Begle (1979).

One of these studies was carried out by Schofield (1981) in Australia. It involved 251 final year primary school student-teachers at two different colleges and more than 1,000 children in grades 4-6. The instrument used to measure the student-teachers' attitudes towards mathematics and its teaching was a semantic differential scale used in a previous study conducted by Schofield and Start (1978). The pupils' attitudes towards mathematics and achievement were assessed by instruments that had been previously found suitable for children. The pupils were tested twice, at the beginning and towards the end of the academic year, whereas the student-teachers were only tested at the beginning of the academic year. Schofield found a clear positive association between the student-teachers' attitudes towards mathematics and the pupils achievement in mathematics, and a weak negative relationship between the student-teachers' attitudes and those of pupils. Schofield points out that his findings appear to give support the idea that "teacher behaviours that enhance the acquisition of mathematical skills in pupils may conflict with those that enhance the development of favourable attitudes toward the subject" (p. 470). However, the author is cautious enough to note that in interpreting his results one should take into account that teachers in this study were at the beginning of their careers and, therefore, they might be especially concerned with their effectiveness in terms of pupils' cognitive results.

Without getting into an involved debate about the possible flaws of Schofield's research, it may be suggested that his study, like many of the studies undertaken prior to Begle's (1979)

contention, was rather atheoretical. For example, teachers' attitudes towards mathematics were only defined in operational terms and there seemed to be no conceptual framework which would help to relate teachers' attitudes to pupils' outcomes. Thus, although there might be no incompatibility between Schofield's findings and his suggestion about teachers' behaviour, it is at least important to recognise his failure in talking about behaviour when he limited investigations to teachers' attitudes as assessed by a paper-and-pencil instrument.

Another large-scale study aimed at investigating the relationship between teachers' attitudes and pupils' attitudes towards mathematics was that by Haladyna, Shaughnessy, and Shaughnessy (1983). These authors postulated a model in which what they label as teacher *quality* (rather than attitude) was considered as a main determinant of pupils' attitudes towards mathematics. Teacher quality is a general concept related to the extent the teacher enjoys and knows mathematics, as well as to his/her commitment to help pupils learn, fairness, praising and reinforcing of pupils work, and attention paid to pupils. In turn, pupils' attitude toward mathematics is defined as "a general emotional disposition toward the school subject of mathematics", thus referring exclusively to pupils' feelings about the subject. In order to test their model, these researchers developed an inventory to assess its different components. The instrument was administered to over 2,000 students in grades 4, 7 and 9 in the U.S., who were selected by using a stratified random sampling plan. Using path analytic techniques, the researchers tested the model separately for the different grade levels. Pupils' attitudes toward mathematics were found to be influenced by teacher quality at all grade levels, the influence strengthening with grade. In turn, what the authors called student motivation (a concept related to pupils' academic self-image, general importance attributed to mathematics, and tendency to accept fate as determining achievement outcomes) was influenced by teacher quality at grade 4, but not at the other grades. On the whole, the study seems to be well grounded theoretically, and does constitute a valuable contribution to the study of the effects of teachers on pupils' affective outcomes. Note, for example, that in contrast with Schofield (1981), Haladyna *et al.* (1983) recognised the possible influence of other variables rather than teacher ones on pupils' attitudes. One of the study's major shortcoming is that the variables thought to affect pupils' outcomes were exclusively assessed by the pupils themselves.

The conclusion that teachers' attitudes towards mathematics and mathematics teaching do influence pupils' mathematical outcomes is obviously an important one. From this perspective, it becomes worthwhile to study teachers' attitudes and to engage in efforts to 'improve' them. Nevertheless, it is equally important to come to understand how teachers' attitudes interact with classroom events so things turn out successfully. One of the studies relating teachers' attitudes towards mathematics and mathematics teaching with pupils' mathematical outcomes that adopts such a standpoint is that by Peterson, Fennema, Carpenter and Loef (1989). The study

involved 39 first grade teachers of 27 schools in the U.S., and their pupils. In comparing this study with the two studies just described, two points stand out. First, this study tends to focus upon teachers' attitudes towards a specific content domain within mathematics (addition and subtraction) rather than on mathematics in general. The other distinction concerns the fact that the researchers concentrated on teachers' cognitions, namely on what they called teachers' pedagogical content beliefs and teachers' pedagogical content knowledge (in addition and subtraction). Teachers' pedagogical content beliefs were conceptualised in terms of four constructs: (1) how children learn mathematics; (2) the relationship between mathematical skills and understanding, and problem solving; (3) the basis for sequencing topics for instruction; and (4) how mathematics should be taught. Teachers' pedagogical content knowledge concerned the information teachers held about word-problems types and solution strategies, as well as procedures to assess children's cognitions in this area. A variety of techniques was used to assess teachers' content beliefs and knowledge: a belief Likert-type questionnaire, a belief structured interview, and non-structured interviews. The teachers were also observed in their classrooms for one academic year. The teachers' pedagogical content beliefs about the four constructs investigated varied greatly. Based on their scores on the Likert-type questionnaire, two groups of teachers could be identified: teachers with a cognitively-based perspective (those teachers who scored high on all the four constructs), and teachers with a less cognitively-based perspective (those teachers who score low on all those constructs). In turn, pupils' achievement was assessed by two tests: a computation and a problem-solving one. In comparing those two groups of teachers, the researchers found that teachers' pedagogical content beliefs were related to pupils' ability to solve problems (in addition and subtraction). Interestingly enough, teachers' beliefs were not related to pupils achievement in computational skills. Moreover, teachers' beliefs were related to their pedagogical content knowledge, their choice of mathematics content, conceptions of the roles of teacher and learner, and goals for instruction. Further relevant findings of this study related to the participating teachers' pedagogical content beliefs are discussed in subsequent sections.

Influence on teachers' instructional practices

A few investigations have examined the relationships between teachers' attitudes towards mathematics and mathematics teaching, and their instructional practices. Three similar, but from somewhat different vantage points, studies were carried out in the U.S.. All of them focused upon the potential of usefulness of conceptual systems theory to understand teachers' practices. Rather than using the term *attitudes*, these authors opted for the term *conceptions*. These were defined by one of these authors as "the set of beliefs and the set of disbeliefs held by the teachers about mathematics and its teaching [...] (as well as the) concepts formed about the subject matter and its teaching" (Thompson, 1982, p. 12). Most of these studies reports are descriptive and the analysis is divided into different sections, each presenting a case study of

each of the teachers participating in the study. In addition, the authors provide cross-case analysis in which they look at some issues of interest across the teachers in order to integrate their findings.

One such study was carried out by Thompson (1982). It involved three junior high school mathematics teachers. The three teachers were observed while teaching their classes over a period of four weeks. During the last two weeks, they were interviewed after each observed lesson in order to clarify specific events of the day's lesson. Supplementary data consisted of teachers' rankings of opinions related to different aspects of mathematics teaching, namely instructional goals and objectives, desirable pedagogical practices, reasons for pupils' insufficient progress, and signs of teaching effectiveness. The teachers' conceptions of mathematics were also assessed in terms of six bi-polar dimensions that may be used to describe the subject. The three case studies are illustrative of three teachers who held a variety of views about mathematics, both in terms of comprehensiveness and integratedness, yet with some points of contact (for example, all the teachers focused on the logical aspect of mathematics). In addition to the differences in their conceptions of mathematics, the three teachers differed in their conceptions of mathematics teaching. Thompson's study provides qualitative evidence of a strong relationship between teachers' conceptions of mathematics and their conceptions of mathematics teaching. However, the relationship between teachers' conceptions of mathematics and mathematics teaching, and their instructional behaviour seemed to be a weak one. She points out that one key factor that appeared to account for this weak relationship was that teachers' beliefs about mathematics teaching were not subject specific. Moreover, she suggests that the relationship might be stronger in cases in which teachers tended to reflect upon their practices in the classroom.

McGalliard (1983) carried out a similar study involving four high school teachers. The aims of the study were to investigate teachers' conceptions of geometrical knowledge as communicated through instruction, and teachers' expressed opinions about the aims of teaching geometry and evaluative assessments of students. The teachers were observed intensively in their classes for a period of three weeks. Additional data consisted of an initial interview, stimulated recall interviews to be conducted in connection with audiotapes of teachers' lessons, and written responses to a set of questions focusing on different aspects of teaching geometry obtained subsequent to the observation period. The major findings of the McGalliard study indicate that the four teachers communicated through instruction similar conceptions of geometrical knowledge. Moreover, they also held similar opinions about the aims of teaching geometry. The author notes, for example, that none of the teachers mentioned the appreciation of the geometry in the real world. Interestingly, the teachers differed greatly in their assessments of

their pupils, thus suggesting that these are influenced by other factors rather than subject matter related ones.

Kesler (1985) investigated four high school mathematics teachers' conceptions of mathematics and mathematics teaching, and the relationship between these conceptions and their instructional behaviour. Kesler's study also aimed at examining the influence of teachers' level of dogmatism (emphasis on the role of authority) on teachers' practices. Case studies of the four teachers were conducted lasting five weeks. Participant observation, audiotaping of class sessions, stimulated recall interviews, the Rocheach dogmatism scale, and a 'Conceptions of Mathematics Inventory' especially developed for the purpose of the study were used to gather data. It may be interesting to note that in contrast to the two previous studies Kesler did not focus on the aims of teaching mathematics. Instead, he examined teachers' conceptions of pupils' understanding of mathematics and of the role of the textbook in teaching. Moreover, he provides some information about the settings of the teachers' schools and of the classrooms climates. The findings of the study supported the author's original assumption that teachers' conceptions of mathematics and mathematics teaching influenced the way they teach the subject. However, the teachers' level of dogmatism did not appear to play a significant role in affecting their practices.

A study carried out in England by Lerman (1986) attempted to present further evidence about the existence of a relationship between teachers' views about mathematics and views about mathematics teaching, and their instructional practices. Unlike the previous three studies, Lerman's work draws heavily on alternative philosophical views of mathematics. He identified four of these perspectives (Logicism, Formalism, Intuitionism and Lakatosian), but he argues that it is possible to arrange teachers' views and actions along a single continuum whose extremes are at the one end the Lakatosian or fallibilist perspective and at the other the Euclidean or absolutist view. According to Lerman, the absolutist or Euclidean perspective considers mathematics as "based on indubitable, value-free, universal foundations". The opposed perspective, the Lakatosian or fallibilist one, considers mathematics as a "social invention, its truths and concepts being relative to time and place". Lerman (1983) suggests that "choice of syllabus content, teaching style and students' attitudes towards mathematics are all determined by the philosophical choice a teacher makes 'even if scarcely coherent'" (p. 62). Associated with the absolutist perspective of mathematics would be the teacher as "the possessor of knowledge", whereas the fallibilist view of mathematics would be mirrored in class through the active participation of pupils "involved in the process of doing mathematics".

Lerman's (1986) empirical work to test his hypothesis initially involved nine mathematics teachers in a secondary school. In order to assess the teachers' views of the nature of

mathematics and mathematics education Lerman developed a Likert-type attitude questionnaire which incorporated statements about mathematics and mathematics education reflecting either an absolutist or a fallibilist perspective. The teachers' answers to the questionnaire were further complemented by means of short interviews. In order to assess their ways of teaching, teachers were observed by the researcher on several occasions and in different classes. As a tool for lesson observation Lerman made use of a system of recording, involving nine categories of pupil-teacher interaction. Despite the appearance of a wide diversity of the teachers' views about mathematics and mathematics education as expressed by their answers to the questionnaire and interviews, Lerman found a considerable uniformity in the teachers' practices in the classroom. The author identified the social context of the school as a strong determinant of the teachers practices.

Ignoring differences of conceptualisation and measurement, the above-cited studies suggest that teacher's views and beliefs about mathematics and its teaching play an important role in their practices. However, these studies have not established a clear relationship between teachers' attitudes and behaviour in the classroom.

One reason for the lack of strong relationship is inherent in the phenomena under study. As already suggested the attitude-behaviour field is enormously difficult to study and the research gap in this debate is especially notable. Another issue raised by some of the above authors is that of the existence of contradictory views about the nature of mathematics held by teachers. One may wonder whether the teachers' apparent ambivalences emerge from two distinct but related objects, mathematics and school mathematics. Teachers have experiences with mathematics during their lives which result from two quite different situations: as learners and as teachers. It may be that as a result of those experiences an integrated view of mathematics has emerged, but it is also possible that they have led to two separate unrelated views. It seems therefore useful to consider two forms of mathematics: one as an academic discipline and the other as a school subject, and assess teachers' views about them. Finally, though these studies were not especially concerned with the factors which may explain the teachers' attitudes, they do in fact attempt to resolve some of the noted discrepancies by indicating some variables which account for them. For example, as already stated, Lerman (1986) considers that the 'specific school context' is a strong determinant of mathematics teachers' instructional practices. In turn, Thompson (1982) emphasises the role of personal factors, and in particular, the teachers' level of reflectiveness as a major factor in explaining the gap between their conceptions of mathematics and mathematics teaching and their actions in the classroom.

Influences upon teachers' attitudes towards mathematics and mathematics teaching

If it is agreed that attitudes are developed over time by means of a series of experiences, then it will be interesting to know which and how these experiences are integrated to form those attitudes. The empirical literature on teachers' attitudes towards mathematics and mathematics teaching suggests that there are two major classes of variables that are perceived as influencing those attitudes. The first group consists of the characteristics of the teacher. These include, for example, teachers' mathematical background and number of years of teaching experience. Secondly, there is some evidence to suggest that certain aspects of teachers' attitudes towards mathematics and mathematics teaching can be considerably influenced in a relative short period of time through their participation in staff development programmes. The following addresses these two issues.

Influence of teachers' characteristics upon their attitudes

Almost every study that examines teachers' attitudes towards mathematics and mathematics teaching makes some mention of their personal characteristics. However, most of these references are on the level of particularities and tend not to point out such characteristics that influence those attitudes. Nevertheless, two main variables can be identified in the research on teachers' attitudes which seem to have a considerable impact: teachers' mathematical background and length of teaching experience.

In a study of four high school mathematics teachers, Rector and Ferrini-Mundi (1986) found that the teachers' background in mathematics does influence their attitudes towards mathematics and mathematics teaching. Two of these teachers had had a normal training for teaching mathematics, whereas the other two teachers were 'converted' teachers of mathematics, that is, teachers whose training was in other areas than mathematics, but who became teachers of mathematics due to the shortage of teachers of the subject. At the time of the study, these four teachers were enrolled in a geometry course as part of seven-week summer institute. Data about the teachers' attitudes towards mathematics and mathematics teaching were obtained through clinical and stimulated-recall interviews, as well as a diary of their activities in the geometry course. The researchers found striking differences between the two pairs of teachers. For example, the 'converted' teachers appeared to hold unelaborated views of mathematics (e.g. mathematics is a comparison of numbers) and profess a didactic view of teaching/learning the subject (e.g. the best way to learn mathematics is to practise the procedures until you master them). Moreover, as participants in the geometry course the 'converted' teachers felt less confident in learning and less at ease with the non-directive approach of the geometry course throughout the sessions than the other two teachers.

Another study which gave further support to the idea that teachers' attitudes towards mathematics and mathematics teaching are influenced by their previous mathematical background was that by Owens (1987). This study involved four pre-service secondary mathematics teachers involved in a post-student-teaching seminar. Data about their attitudes (the author uses the term *constructs*) were gathered through the use of repertory grid techniques. In addition to complete elicitation and ranking instruments which are characteristic of this approach, each teacher participated in a series of seven one-hour interviews. In this study, two sets of elements were considered for the elicitation of personal constructs: mathematical topics and teaching roles. Fifteen personal constructs related to the mathematical topics were elicited, including criteria such as easiness, likeability, usefulness, abstractness and creativity. In turn, the teaching roles elements gave origin to seventeen personal constructs that focused on personal, non-intellectual individual qualities. One of the findings of the author is that constructs relating to mathematics were affected by prior success with pre-college mathematics. It is possible that Owen's study has produced useful knowledge. My point of bringing his study to this review, however, is not so much because of its contribution to the knowledge in the field as with the methodology that was used in the study. As already stated repertory grid techniques are difficult to administer. The short report of the study reviewed here seems to suggest that the results provided by repertory grid largely remain inaccessible to readers who are not familiar with such techniques.

The influence of length of teaching experience on teachers' attitudes is well documented in the research on teaching in general. For example, Berliner, (1987) shows that more and less experienced teachers differ in the ways in which they think about their pupils and classroom practices. The same might be true in relation to mathematics teaching as well. For example, the study described earlier of Peterson, Fennema, Carpenter and Loef (1989) shows that the teachers' pedagogical content beliefs were related to the length of teaching experience: the more experienced teachers tended to have a more cognitively based perspective (that is, they tend to build their mathematics teaching on what pupils already know) than the less experienced ones.

Influence of teachers' participation in in-service upon their attitudes

Much of the early research on how teachers' attitudes towards mathematics and mathematics teaching were influenced by their participation in staff development programmes involved student-teachers as they were going about their courses as part of their training as teachers. Because these studies may suggest ways of developing appropriate designs for assessing attitude change, the decision was taken of including them here, in spite of the fact that the kinds of experiences teachers have at pre-service level are quite different from those of in-service teachers.

In the U.S., Collier (1972) carried out a study with 260 primary student-teachers who were at four different stages in terms of the mathematics and mathematics methods courses taken in the college. The author developed two Likert-type scales which set out to assess student-teachers' views about mathematics and its teaching in terms of a formal-informal dimension. He also developed a measure aimed at assessing students' ambivalence of beliefs about mathematics. Collier found that the student-teachers who had completed the mathematics related courses in the college had more "informal" views about mathematics and mathematics instruction and were less ambivalent in their beliefs than those students who have just entered the college. The fact that the study was a cross-sectional rather than a longitudinal one, led the researcher to be particularly cautious in interpreting the results as indicating that student-teachers do change their attitudes as a consequence of their initial training in college.

The study by Lumb and Child (1976), in England, provides further insight on this issue. These researchers followed a group of 296 student-teachers through their two early years at the College of Education to examine the possible influence of training courses on student teachers' attitudes towards mathematics and its teaching. These were assessed on entry to the college and again after the students had completed two mathematics courses. Different types of measures were used to assess students' attitudes. A shortened version of a semantic differential scale (which had been shown to be an effective way of assessing pupils' attitudes towards mathematics in U.S.) was used to assess student-teachers' views about mathematics. In order to measure their views about the teaching of mathematics the researchers developed a Likert-type scale. In addition, they used a semantic differential scale with the same pairs of bi-polar adjectives that formed the basis of the attitudes to mathematics semantic differential scale. The results were analysed in terms of sex groups and of the age-range that the prospective teachers would be teaching. In comparing the students' attitudes scores at the end of the two years with those at the beginning, it seems that those students who have opted for teaching in first schools and especially female students appeared to have substantially shifted their attitudes towards mathematics. The same pattern of results could be found in relation to students' attitudes towards the teaching of mathematics as measured by the semantic differential scale. No clear pattern, however, seemed to emerge from the results of initial and final answers to the items included in the Likert-type scale.

By the time that Lumb and Child's (1976) study was made public, developments in both the areas of attitude assessment and change, and teacher education had already begun to provide new ways of thinking about these issues. In regard to the first topic, criticisms were being raised as to the crudeness of the paper-and-pencil tests used in the studies and the little more than indiscriminate use of scales to measure people's attitudes. Within the mathematics education community, concerns were particularly prominent as to the breadth of the idea of

attitudes towards mathematics. For example, Fennema and Sherman (1976) suggested that different individuals may have favourable or unfavourable attitudes towards mathematics in different ways, on different levels and for different reasons. They accounted for this situation by using nine domain-specific Likert-type scales in a study aimed at investigating pupils' attitudes towards mathematics.

In the field of teacher education, flowing from the relative failure of the curriculum development projects that characterised the 1960s and early 1970s, the issue of in-service training for teachers was also beginning to be addressed. Thus, from the mid-1970s onwards, attitude change studies have focused upon in-service teachers, as well as pre-service ones. Moreover, there has been a shift in methodological approaches too. Research has changed its emphasis from analysis of exclusive testing of attitude change to studies of the process of change itself. I will start my review of studies that fall within this category by presenting an account of an extensive research project involving a large number of teachers (161) from a considerable number of schools (12) and which lasted for a long period (1976-80) (Biggs, 1983). To the author of this project, the most crucial feature was transforming teachers' practices in the classroom. Yet it is clear that achievement in this direction was associated with changing their attitudes as well. Moreover, while the unit of analysis in this project was the school rather than the individual teacher, I believe that Biggs' study is specially instructive because it was carried out by a person who had extensive experience as an in-service provider in primary mathematics.

The method of investigation used by Biggs (1983) was inspired in an action research paradigm, with the researcher in the role of change-agent working alongside the participating teachers in their classrooms to help them to change their practices. Data were collected in a variety of ways (attitude questionnaire, interviews, observations) and from different sources (teachers, head-teachers). In addition to being provided with the researcher's support visits, the participating teachers attended working sessions during a period of time equivalent to four working days. These working sessions were organised "to give the teachers experience, at first hand, of learning mathematics at their own level by means of activities, and subsequently of adapting these, with their colleagues, for their children" (Biggs, 1983, p.50). In some cases, the working sessions took place in the school involving the head and all teachers. Another type of organisation consisted of having 'key teachers' of several schools to attend working sessions at a the local teachers' centre. The most important finding of the project is that in many cases changes in the teaching of mathematics had effectively occurred in the schools (the percentage of teachers in each school making changes ranging from 20% to 70%), the transformations being in the direction aimed at by the researcher. Another relevant finding was that of the necessity of the head, and in fact of the whole school, to become involved in the

project if real changes were to be made by the individual teachers. On the other hand, there was no evidence that one type of organisation of working sessions (in- versus off-school) was more effective than the other in terms of the outcomes. In short, this experience suggests that change is possible. Moreover, adoption of an action research paradigm within a staff development programme does appear to contribute both to enhance the probability of teacher change and to increase understanding of the dynamics of the process of change.

Recently, other less demanding and less complex projects have shown the efficacy of in-service courses in influencing teachers' attitudes towards mathematics and mathematics teaching. For example, in Canada, Dionne (1986, 1987) conducted a study involving 34 primary teachers of which eighteen were enrolled in an in-service mathematics education course (the remainder sixteen teachers were taking a course in a field other than mathematics and were used as a control group). In order to assess what Dionne calls the teachers' *perceptions* about mathematics and mathematics teaching, three tools specifically developed for the purposes of her research were used: (1) a "correction test" aimed at investigating the focus that the teachers put on pupils' answers; (2) a written questionnaire to assess the extent to which the teachers endorsed three distinct views of mathematics previously identified as traditional, formalist and constructivist; and (3) a long interview aimed at exploring their perceptions of mathematics teaching and learning, namely in relation to the place and role of intuition, understanding and skills, discovery processes, and errors. All the participating teachers were given both the correction test and the written questionnaire, once before and once after the course. The interviews, prior to and after the course, were carried out only with twelve of the teachers (six in the experimental group and six in the control one). In concentrating her attention on these twelve teachers, Dionne (1987) concluded that "five out of the six of the experimental subjects reveal a real influence of the experimental course" on their perceptions (p. 91). This conclusion is, however tempered by her contention that "it will always be sheer utopianism to try to change someone's convictions against its own will" (p. 91). Indeed, the five teachers who appeared to be most influenced by their participation in the course were those who were already in tune with the message conveyed by the course.

Another study that gives further support to the idea that what teachers get out from courses is determined to a large extent by what they bring into them is that of Waxman and Zelman (1987). The subjects participating in this study were nine pre-service and six in-service teachers who attended a course aiming at facilitating reflective awareness of their beliefs about learning, teaching and mathematics. A variety of techniques were used to tap these beliefs. These included among others: (1) a mathematical autobiography; (2) videotaped clinical interviews; (3) a projective test; and (4) pre-, post- and follow-up questionnaires. Based upon the data collected on the fifteen participants' beliefs, the authors identified three essentially

different prototypes of pre- and in-service teachers: *traditionalists*, *reflective math-phobics*, and *constructivists*. The researchers indicate major differences between the ways in which these three groups of teachers interacted with the course. For example, whereas the traditionalists did not feel at ease with many of the course activities, for the constructivists the course constituted an opportunity "to incorporate reflective processes into teaching practices" (p. 147). In turn, the course seemed to have contributed to make the reflective math-phobics aware of the discrepancy between their beliefs and practices. In addition, this latter group of participants appeared to have become more interested in children's learning processes.

The study by Peterson, Fennema, Carpenter and Loeff (1989) described in an earlier section also addressed the issue of the influence of an in-service course on the teachers' pedagogical beliefs and content knowledge (Fennema, Carpenter and Peterson, 1989). Following initial data collection about the beliefs and knowledge of the 39 participating teachers, the sample was randomly divided into two groups (experimental and control). The teachers in the experimental group attended a four-week summer in-service course, and were afterwards observed in their classrooms for 16 days over a period of four months. The focus of the in-service course was on what Fennema, Carpenter and Peterson call cognitive guided instruction (CGI), that is, instruction placing emphasis on: (a) children's ability to construct their own knowledge; and (b) pupils' understanding of relationships between concepts, problem solving and skills. The researchers note that after the course the experimental teachers' beliefs and knowledge "became more cognitively guided" than those of control teachers (p. 184). Moreover, in comparing the instructional practices of the experimental and of the control groups after the in-service course, the researchers indicate that there were considerable differences. They sum up the results of their observations by stating that "CGI teachers did spend considerably more time than did other teachers having children solve word problems in a variety of ways, and they they did spend more time listening to the children describe their mental processes as they solved problems" (p. 185).

Summary

This section has examined teachers' attitudes towards mathematics and mathematics teaching from two perspectives: what teachers' attitudes influence and what influences teachers' attitudes. An initial point that emerges from this section is that there are no commonly-accepted conceptualisations of teachers' attitudes towards mathematics and mathematics teaching, nor approaches to assess them.

After the analysis of the different possibilities and interpretations of assessing teachers' attitudes towards mathematics and mathematics teaching, and attitude change, one is left with

four further main issues. First, the studies cited throughout this review tend to employ a variety of approaches to assess teachers' attitudes towards mathematics and mathematics teaching. Second, it becomes apparent that it is necessary to reexamine these issues in the light of a research paradigm which is able to provide more than both a mere description of teachers' attitudes and attitude change. Third, it seems important that before studying teachers' attitudes and attitude change, a broad theoretical framework concerned with the analysis of different processes of formation and change should be outlined in order to help in the data collection and exploration procedures. In particular, it is considered essential to try and find factors which may account for teachers' attitudes, an area that has been relatively neglected. Finally, promoting changes in teachers' attitudes through their participation in staff development programmes seems possible, yet problematic, time consuming and highly dependent on what the individual teacher brings to the programme.

TEACHERS, LOGO AND MATHEMATICS

The ultimate purpose of this section is to examine ways in which teachers interact with learning and teaching experiences with the computer and Logo, and how these experiences can be expected to change their attitudes towards mathematics and mathematics teaching. Before that, I will attempt to explain the perspective that I brought into the research (as suggested in Chapter 1), that of Logo as a paradigm for doing mathematics.

Logo as a paradigm for doing mathematics

How might one expect that teachers' learning and teaching experiences with Logo would affect their attitudes towards mathematics and mathematics teaching? In my efforts to design a Logo course which would enable teachers to learn Logo for the task of using it with their pupils, and at the same time would lead them to rethink and broaden their views about mathematics and mathematics teaching, this is an important question to explore and attempt to answer. My own answer would be straightforward: "because Logo is a paradigm for doing mathematics".

However, as stated in Chapter 1, there is still considerable controversy on whether Logo is an effective paradigm for doing mathematics. In my opinion, such a controversy rests, at least in part, on the understanding of what mathematics is about and to a large degree on the lack of correspondence between mathematics and school mathematics. In other words, the conflict Logo versus mathematics is triggered off by the gap existing between mathematics and school mathematics, and this is the problem that requires solution.

With regard to the correspondence between Logo and mathematics, it is interesting to note, for example, that in a recent report of projects related to teacher education in Logo-based environments in seven European countries (Schuyten and Valcke, 1990), all but the Portuguese project considered Logo linked to objectives in relation to mathematics. I would like to suggest that such fact highlights that the authors of the Portuguese project did not regard it as relevant in terms of the objectives of the mathematics school curriculum. This sub-section aims at giving support to the idea that Logo is a paradigm for doing mathematics, as well as school mathematics by drawing on available evidence from research on children working with Logo.

One apparently unproblematic link between Logo and school mathematics is that of Turtle Geometry. There is empirical evidence of such link. For example, a study conducted by Noss (1985) (with pupils of Years 2, 3 and 4 in England) shows that children working with Logo tend to have a better understanding of the concepts of angle and length than those without Logo experience. Also, Olson, Kieran, and Ludwig (1987) conclude (from a study of pupils in two grade 7 classes in Canada) that "Turtle Geometry is a deep activity and not just a set of introductory computer exercises for children" (p. 370). Some authors, however, contend that in a Logo environment "the persistent use of visual schema acts as an obstacle to the understanding of mathematical relationships which are embedded in the given problem" (Hillel and Kieran, 1987, p. 61). Now, it may be true that in face of visual cues, pupils pick up the practical side of the problem and get it done without making explicit existing mathematical relationships. But will it not be the case that this is better than feeling the frustration of not getting anywhere? An approximate solution may have strong affective connotations and may lead to the search of a 'right' solution. The nature of Turtle geometrical knowledge -- knowledge that is directly related to action -- is qualitatively different from 'academic' geometrical knowledge, but is not incompatible with it. It may be argued that it is not necessarily the case of either school geometry or Turtle geometry, but that both can be used to improve children's understanding of geometry. It may be worth noting that the significance of Logo for the learning of geometry, however, was not dismissed by Hillel and Kieran. In a later study, these authors (Kieran and Hillel, 1990) used pre-defined (and hidden) Logo procedures to encourage the learning of specific geometric concepts (isosceles triangles and quantification of angles) and conclude that the Logo environment created did enhance children's understanding of those concepts.

But links between Logo and mathematics are not restricted to geometry. For example, Logo incorporates a number of features that have parallels with algebraic ideas too. Noss (1986), for example, calls attention to the links between the notion of procedure and inputs/variable in Logo to those of function and variable in algebra. Moreover, the results of his above mentioned field experiments with children using Logo show that children's understanding of the concepts

of algebraic variable and elementary algebraic formalisation may increase as a result of their Logo work. Similar results have been reported by other researchers too. For instance, in a longitudinal study of eight children working with Logo, Sutherland (1987) summarises evidence suggesting that "pupils' use of variable in Logo programming is likely to make algebra more meaningful and accessible to them" (p. 277).

Other authors have directed attention to other equally important dimensions in children's learning mathematics while doing Logo. For example, Hoyles (1985) suggests that Logo provides an environment for discussion and reflective experimentation, as well as for illuminating pupils meanings and interpretations of mathematical ideas. To illustrate the point that a Logo environment can provide a context for children to learn mathematics, Hoyles and Noss (1987) propose a model that describes the processes by which pupils operate in such an environment, and provide an instructive example of how children working at a Logo structured task construct links between the visual and formal modes of representation. As an extension of this work, the same authors provide a good illustration of how a series of closely related Logo tasks can be used as a catalyst in children's proportion strategies (Hoyles and Noss, 1989). Reflecting a similar point of view, Leron (1988) maintains that children working with Logo are able to create links between intuitive and formal representations of mathematical concepts. In addition, he sets forth the view that mathematical concepts are often simpler to handle in a Logo programming situation than in a standard mathematics class (e.g. controlling change and constancy).

Allusions have also been made to potential effects of children programming in Logo on the development of their problem solving strategies. The work of Lawler (1985) is replete with illustrations of the positive and exciting impact that working with Logo can have on a child's cognitive development. In the words of Lawler: "It is clear that even the little Miriam [the subject of his study] learned about programming and debugging changed her ability to describe activities in analytic, procedural terms" (p. 112). A final manner in which Logo can enhance children's mathematical learning is by having them to develop mathematical 'software products' designed for use by other children. This approach is well documented by Harel (1990) in a study that involved 51 elementary school children, of which seventeen were engaged in an experience of using Logo to teach and learn fractions. According to Harel: "the children's *personal* goal of representing and explaining fractions to another person helped them to overcome their own difficulties in understanding fractional representations" (p. 31).

Of course, none of the Logo potential for enhancing children's mathematical learning is irrespective of the complementarity of teacher intervention. As Hoyles and Noss (1987) point out: "the teacher must still have the role of focusing attention on points of the activity which are

significant in making explicit other meanings and relationships for the pupils" (p. 165). The case for Logo as a paradigm for doing mathematics is not to dismiss the teacher and the standard mathematics classroom, but that of providing an additional context so that children can increase their understanding of the subject by doing mathematics in a functional way. As already suggested in Chapter 1, when discussing the role of Logo in mathematics education the need emerges for providing teachers with learning and teaching experiences with it.

Teachers' learning and teaching experiences with Logo

A piece of early work aiming at investigating whether teachers' attitudes towards and performance in mathematics were influenced as a result of their involvement with a learning experience with Logo is that of DuBoulay and Howe (1982) in Scotland. The researchers intended to introduce Logo programming in primary teacher training curricula as a means to facilitate the learning of mathematics topics. They carried out two studies involving student-teachers from a College of Education in Edinburgh. The first study involved 48 second-year college students who were enrolled in a mathematics course. Twelve of these students who needed an extra course in mathematics were randomly assigned to a control and an experimental groups. The six students in the experimental group undertook a Logo-based mathematics course at the University where the research team was based, whereas the other six students were taught the same mathematical topics (shape and number concepts) in a traditional way at the College. In the second study, nine third-year college students considered mathematically less able undertook the above mentioned Logo-based course, while the remaining 25 third-year students did not take any mathematics at all. The student-teachers' attitudes towards mathematics and mathematics teaching were assessed through three instruments that had been used by Lumb and Child (1976) in their study of student-teachers' attitudes (two semantic differential scales, and a Likert-type questionnaire). In addition, the students had to answer a set of five questions aimed at assessing the extent to which the students had enjoyed mathematics at various stage of their schooling. The student-teachers' knowledge of mathematics, and in particular of the mathematical topics addressed by the Logo-based course, was assessed by means of tests adapted from existing instruments.

These two studies had been preceded by a pilot study with fifteen student-teachers who considered themselves having difficulties in mathematics and volunteered to participate in it. This pilot study provided a basis for the design of the Logo course in the main studies. A salient feature of this course was the little emphasis on programming with Logo. In fact, as a result of the pilot study the researchers had concluded among other things that: (a) programmes to be written by the students should be short and should deal with the properties of the mathematical objects or processes under consideration; and (b) reworking algorithms in

programming notion is not in itself a useful activity for student teachers to undertake (DuBoulay, 1980, p. 359). A second feature of the course was that it followed a highly structured pattern with the students working through worksheets with clearly explicit assignments, thus differing dramatically from the approach suggested to be used with pupils by Papert (1980).

The findings of the study are quite disappointing in terms of both changes in the student-teachers' attitudes and gains in their performance in mathematics. Only the second-year students appeared to have improved considerably their scores in the shape and number tests. DuBoulay and Howe (1982) state that "it would be quite unrealistic to expect that 10-20h of computer-based instruction spread over a year, would produce a startling improvement in students who had struggled with the subject in the classroom for many hundred of hours" (p. 98). If so, why did the researchers undertake the studies in first place? The authors also point to factors which could not be properly controlled within the study, as contributing to the unsatisfactory results. For example, the researchers note that in the first study the characteristics of the students in the experimental group were different from those in the control one. Given the small number of students participating in study, this is hardly surprising. It may be suggested that what was inappropriate was the methodology used in the study and not what emerged as a consequence of a faulty approach. Indeed, one may also speculate that if the researchers wished to instil 'new' attitudes towards mathematics, then the strategy pursued of using a very structured approach to teach 'old maths' stuff was not the most appropriate. Of course, the use of a new remedy is not *per se* a panacea for an old illness.

A different approach to analysing the implementation of Logo in student-teachers' courses was that followed by Mitchell (1983). The subjects involved in Mitchell's study were 50 university students enrolled in a mathematics content course for elementary teachers. Two main issues investigated by the study were: (1) whether the student-teachers learn mathematics as a result of their experience with Logo; and (2) whether they would change their attitudes towards mathematics and computers.

The design of the study followed a quantitative paradigm, with the students being tested on the variables under scrutiny both before and after the Logo experience, and the results of the tests analysed statistically. Four components of the Fennema-Sherman Mathematics Attitudes Scales (Fennema and Sherman, 1976) were used to assess student-teachers' attitudes towards mathematics. Other instruments used in this research included both tools specifically developed for the purpose of the study and tests developed by an educational testing service (e.g. the Mathematics Basic Concepts Test). Further data were collected by means of the daily records of the student activities on the computer and observation of eight of the students (four pairs) by a team of external observers.

The student-teachers' experience with Logo lasted for seven weeks, with three sessions per week following a pattern of a hands-on session alternating with a discussion session. The course sessions were held at extra time that was added to the students' normal schedules. The course, which according to the author drew heavily on the model used by Papert, Watt, DiSessa and Weir (1979) in the Brookline Logo Project, was run by the researcher himself. The study report provides detailed plans of the sessions with the specific indication of and information about the Logo commands introduced in each of the sessions, thus suggesting that the author followed a highly structured teaching approach. A large part of the lesson plans concerns operations and knowledge of the Logo programming language. As the Logo learning experience was also concerned with changing the student-teachers' attitudes, it is quite surprising that affective objectives are so rarely mentioned as a cue for the sessions' activities.

Analysing the influence of the course on the student-teachers' attitudes towards and knowledge of mathematics in terms of their scores in the pre- and post-tests, Mitchell claims that as a result of their experience with Logo the student-teachers: (a) increased confidence in their ability to learn mathematics; and (b) had a positive change in attitude toward the usefulness of mathematics. Moreover, those students who had a 'high' mathematical background and were successful in learning to programme in Logo increased their motivation to study mathematics. No changes appeared to have occurred in the students' attitude toward success in mathematics, that is, in the extent to which they anticipate positive consequences as a result of success in mathematics. With regard to the possible influence of the experience in the student-teachers' mathematics knowledge, the findings of the study are in Mitchell's opinion somewhat surprising. For example, the researcher found that whereas programming with Logo might have contributed to increase the participants' knowledge of algebra, the experience did not contribute to increase their knowledge of geometry. In fact, the author referred that some of the participants with a 'low' mathematical background even felt confused as a result of the experience. The student-teachers' mathematical background appeared also be related to the extent to which they 'improve' their attitudes towards computers.

The black box approach makes it obscure to understand the conditions in which and why these changes occurred or did not take place. In spite of the possible drawbacks of the study, it provides some evidence as to the potential that an environment Logo has to affect teachers' attitudes towards mathematics. It is also relevant that the study findings suggest that student-teachers' background variables such as the ones related to their mathematical abilities may play an important role in determining the kind of effects the Logo experience has on teachers' attitudes towards mathematics and towards computers.

Finally, it may be relevant to mention that during the study the researcher was led to alter his initial plan for the course, suppressing some of the sessions. This appeared to have been so owing to the fact that the student-teachers felt overwhelmed by the great amount of material to be covered. As Mitchell (1983) notes, curtailing some of the sessions might have been helpful in diminishing their frustration in subsequent ones. The author also noted that the students were especially reluctant to participate in the discussion sessions.

This discussion is worth two observations. First, it leaves open the possibility that Logo may be a paradigm for teachers doing some mathematics. Second, it is of some interest that DuBoulay and Howe's study points to somewhat unsatisfactory results in terms of student-teachers' improvement in mathematics and Mitchell's work suggests the opposite. Clean empirical connections cannot probably be made between teachers learning/teaching with Logo and relevant changes in their achievement in and attitudes towards mathematics. It is reasonable to expect that the kinds of experiences teachers have in learning/teaching with Logo, as well as their personal characteristics affect what happens to them. Thus, monolithic assertions about any common property's effect on teachers as a result of their experiences with Logo are dubious. This, in turn, suggest that a case-study or ethnographic approach rather than a pre- and post-test experiment should be used for examining possible changes in teachers behaviour and attitudes. The remainder of this sub-section deals with investigations of teachers' learning/teaching experiences with Logo which fall in the former of those two categories.

In the U.S., Ferres (1983) carried out a study aimed at examining the influence of a learning/teaching experience with Logo on teachers. Even though the study is not specifically concerned with mathematics, it is still useful in providing us with the contingencies among teachers learning and teaching with Logo, their process vicissitudes and their consequences. The major aims of the study were to assess: (1) the participating teachers' development of understanding of Logo capabilities and the process of teaching with Logo; (2) the transfer of personal skills in Logo to appropriate use in classroom; and (3) the use of Logo by the pupils of the 'trained' teachers. Eleven elementary and middle school teachers, with and without computer experience, and varied teaching experience volunteered to participate in this study. It may be worth mentioning that all the participating held posts of responsibility, and that seven of the teachers held a Masters degree.

The study comprised three sequential phases, each phase being, broadly speaking, related to each of the three above mentioned aims. The first phase consisted of five consecutive morning Logo workshops preceded by a one-hour orientation session. These university-based sessions, which aimed at the development of teacher skills with Logo, were followed by a four-week "coaching" (Joyce and Showers, 1980) phase during which the teachers used Logo in their

classrooms with the assistance of the trainer, as well as met once a week to share experiences in teaching with Logo (second phase). The third phase consisted of the implementation of Logo in the classroom. Data were collected in a variety of ways. These included the teachers' daily report forms and course tutor's observations during the workshop, and data of more closed nature such as those obtained by structured interviews (at the beginning of the first phase and at the end of the second one), and a Logo skills test at the end of the first phase. Moreover, at the beginning of the first phase, the course participants' conceptual level (a construct related to orientation to learning and reflectiveness) was assessed by means of a Paragraph Completion test developed previously by other authors.

Although Ferres (1983) stated that the nature of the research suggested a case study reporting procedure, the findings of the study are mostly presented as a cross-case report focusing upon issues judged of interest. Brief sketches of the participants were only used to report findings related to the second and third phases of the study. The research findings include the identification of two variables as accounting for the teachers' development of Logo skills, namely previous experience with Logo (but not previous experience with teaching with or about computers), and length of teaching experience (more experienced teachers tended to be less successful in learning Logo than the less experienced ones). It is somewhat surprising that Ferres did not mention teachers' mathematical background at all, as previous research had indicated this variable as most influential on teachers' learning Logo. With regard to the implementation of Logo in the classroom, Ferres reported that a positive relationship appeared to exist between the teachers' level of success in learning Logo skills, and implementation performance and effectiveness. Other factors which seemed to be associated with the ways the teachers implemented Logo in the classroom were classroom organisation, and school support and resources. For example, the author notes that for teachers who were only accustomed to whole class teaching, the management of the class with some of the pupils working with Logo became a major concern.

Despite the fact that the in-service course evaluation was not one of the aims of Ferres' study, the author puts forward his perceptions about the course, as well as some suggestions for possible alterations. First, he points out that the teaching component of the programme should be more emphasised at its beginning rather than being almost exclusively dealt with in the final sessions. In this regard, it may be interesting to note that when the issue of Logo implementation was considered by the first time in one of the final course sessions, several teachers would have preferred to continue with increasing their own development with Logo. Second, he considers that the development of certain skills could be implemented by means of the use of more structured learning materials. A further issue addressed by Ferres concerns the need for extensive support by the trainer for the participants during the implementation and

follow-up phase, and the problems. Finally, Ferres recognises that the presence of participants teaching a wide age-range group of children brought some problems at the later stage of the course in that their needs diverged, but yet they were all doing the same.

In England, a major research project on the use Logo in teacher education was that carried out by Hoyles, Noss and Sutherland (1991). In this study, however, the participating teachers' experiences with the computer were not restricted to Logo, but include other mathematical software packages as well. The purpose of the two-year investigation was twofold: (1) to assess the course participants' views and attitudes towards mathematics, mathematics teaching, and computers; and (2) to describe and analyse the course participant's interactions with the course, and in particular to examine the ways in which their attitudes influenced and were influenced by their participation in the course. As part of their investigation, Hoyles *et al.* designed, implemented and evaluated a university based computer in-service course designed for the purpose of the research which included a Logo component. The 30-day course sessions were distributed over the whole academic year following a pattern consisting of three day blocks and single days at fortnightly intervals. Between the sessions the participants were expected to continue and extend the sessions work at their own level as well as to use the computer with their pupils in their classrooms. Participants were also expected to develop and implement a computational microworld related to some aspect of the curriculum. Twenty secondary mathematics teachers, thirteen in the first year of the study and seven in the second one, participated in the study. Most of the participating teachers held positions of responsibility related to mathematics and/or computers within their schools.

Data were collected in a variety of ways: (a) semi-structured interviews at the beginning, mid and end of the course; (b) examination of project work (microworlds) by teachers; (c) observation notes of participants' work during the sessions; (d) classroom observations; (e) examination of participants' case-studies of pupils; and (f) post-course questionnaires. The methodology to analyse the data followed mostly a qualitative paradigm. In the first instance, case studies of each course participant were written. These served as a basis for carrying out the course evaluation, and for the presentation of the findings related to the above mentioned aims of the research. The findings are reported in quite a singular way. Based upon the data collected from the individual participants, the researchers developed five "caricatures" of teachers, and presented case studies of these five caricatures. The intention was not to group the participants into five prototypes, but to create stories of five imaginary teachers who might well have attended the in-service course. In an appendix, the researchers present three case studies of three real participants as well.

Of special significance is the finding that the participating teachers did not change substantially their views of mathematics, nor their feelings towards the subject. In contrast, it seems that, in general, there were considerable shifts in the participants' attitudes towards the use of the computer in mathematics. In terms of changes in the teachers' attitudes towards mathematics teaching, these appeared to occur in the direction in which a participant's thinking was already developing and were associated with his/her commitment to change before the course started. As to the implementation of the computer and Logo, the participants tended to report difficulties related to both problems of access to computers and lack of support from other members of school. Moreover, the authors suggest that the participants who seemed to be less committed to use the computer in the classroom, and in fact stopped using it after the course, were those who throughout the course sessions showed less willingness to engage in computer activities aimed at personal development.

In evaluating the course, Hoyles *et al.* (1991) consider that the structure of the course (e.g. scheduling of the sessions) and the activities and materials provided were most appropriate. In particular, the researchers stress the importance of providing materials which can be used by pupils in classroom, and at the same time the need for having teachers to develop their own materials. In this regard, it is worth noting that many participants expressed some disappointment with the activity of developing a microworld. Nevertheless, the researchers consider that although the outcome of such activity might have been disappointing, the process of undertaking it was a valuable one.

At this stage, it may be useful to point to a couple of common issues emerging from Hoyles, Noss and Sutherland (1991), and Ferres' (1983) studies. First, it is interesting to note that most of the participating teachers in both studies hold posts of responsibility, and in the case of the Ferres' course most of them held a Masters degree. This is in agreement with the analysis offered by Guskey (1988) suggesting that teachers who volunteer for attending new programmes "are likely to be those who are already very talented and highly effective instructors" (p. 68). Presence of "talented and highly effective" teachers in the two studies means that one should be especially careful in interpreting their findings. Another commonality could be noted in the two studies. Although the two courses differ rather substantially both in structure and theoretical orientation, both authors stress the difficulties felt by the participants in implementing computers in classroom, and therefore the strong need for elaborate systems of support. The message may simply be that other systems of in-service provision rather than university-based ones are more likely to be effective if the aim is to have teachers using an innovation in the classroom. Alternatively, one may speculate about the impossibility of changing teachers practices without changing their attitudes and/or without changing environmental conditions.

The common problem emerging from these two studies related to innovation implementation in the classroom appears to lend credence to the view in support of in-school based in-service work as opposed to off-school based ones. A major research project concerning the use of Logo by teachers following a in-school based approach was that carried out by Carmichael, Burnett, Higginson, Moore and Pollard (1985) in Canada. In this study, there were no special workshops for introducing Logo to teachers prior to using it in the classroom (in some cases, however, teachers had attended to some computer/Logo courses prior to the beginning the study). That is, Logo was introduced to both teachers and pupils at the same time in their usual classrooms. The study lasted two years (from September 1982 to June 1984) and involved thirteen elementary teachers from nine different schools and their pupils. Because the researchers found it difficult to carry out the investigation with such a large number of subjects, at the end of the first year they concentrated only on five of the teachers and 40 pupils. The researchers were interested in investigating among other things: (1) different aspects of the teaching/learning in a Logo environment; (2) effects of the creative use of Logo in the classroom upon its environment, teacher-pupils interaction, and interaction among pupils; and (3) problems concerning Logo teacher training. Data were collected in a variety of ways (pupils questionnaires, classrooms observations, activity sheets, Logo quizzes, computer printouts of pupils work, as well as interviews and informal meetings with teachers) and were analysed mostly following a qualitative paradigm.

The study focused on the work of the pupils using Logo rather than on that of the teachers, and so the information concerning the teachers' experience with Logo is very limited. Nevertheless, the study is instructive in pointing out some features related to the involvement of the teachers in the experience. For example, in regard to the issue of demands on teachers of coming to terms with Logo in the classroom, the researchers note the difficulties, uncertainties and frustrations felt by the majority of participants in the study. In particular, those teachers who were learning Logo at the same time as their pupils became especially anxious to note that their pupils were advancing very quickly. The authors also note that teachers felt greatly constrained by existing school structures. Here too the issue of using an innovation in the classroom is considered to be problematic. Thus, the question of whether school-based in-service is more effective than off-school one is left largely unanswered.

But Carmichael *et al.*'s study gives support to the idea invoked by Olson (1980) that bringing teachers to use an innovation may promote their reflection upon old attitudes and practices. That is, this study suggests that novelty of the situation in which teachers were placed contributed to bring to light some issues, such as pupils' disparate needs and different rates of learning, which were elusive in a traditional setting. Looking back at the large picture of data, Carmichael *et al.* (1985) state:

Our study found that teachers who were able to change their classrooms into an environment that encouraged creative expression, had to examine very fundamental assumptions about teaching, learning, and their professional role as teachers.(p. 368)

Specifically in relation to mathematics, there are illuminating comments of some teachers in the study's report that suggest that teaching with Logo led them to broaden their views about the subject and its teaching. These comments were in most cases related to geometry (e.g. it is far easier to explore relative size and symmetry in Logo), but there also a few concerning arithmetic as well.

Summary

This section began with the discussion of a general issue of the relationship between Logo and mathematics. The case has been made that Logo can be used as a paradigm for doing mathematics, although involvement with Logo is not enough to guarantee so. The evidence presented in favour of such a case came mainly from studies of children working with Logo, but the idea was advanced that if it works with children, then it works with teachers too.

Then an array of studies of learning/teaching experiences with Logo of teachers and student-teachers were examined in detail. These studies constitute examples in which Logo was used in different ways, and present some evidence that teachers' experiences with Logo may affect their attitudes. Some of the authors seemed to espouse 'revolution' whilst participating in and supporting the status quo (e.g. DuBoulay and Howe, 1982). In these cases, there is no basis for expecting any changes in the teachers' attitudes. In other instances (e.g. Hoyles, Noss and Sutherland, 1991), however, there were teachers whose attitudes were affected as a result of their experiences with Logo, as well as teachers whose attitudes remained essentially the same. This fact is in agreement with the idea that what a teacher gets out from a staff development programme is to a great extent an individual matter.

The discussion has pointed to a couple of common issues that are worth bearing in mind. First, most of the studies seem to lack a theoretical framework in which the teachers' experiences with Logo might be located. In particular, the role of the participating teachers' characteristics (e.g. length of teaching experience) and motivations in filtering the messages and ideas conveyed by the programmes in which they participated appeared to be an understudied aspect.

A second common issue concerns the difficulties experienced by the participating teachers in implementing Logo in the classroom. It is quite interesting that different courses with striking different theoretical orientations, varied durations, based either in university or in-school led to similar results with regard to this particular aspect. If a particular staff development programme is devoted to have its participants to use Logo in the classroom bringing with it new teaching

strategies and different classroom organisation, then the task is not easy. Clearly, bringing about change in the classroom is far beyond of having teachers participating in an in-service course. These findings are a reminder that the political, organisational, and other social pressures are important sources of disincentives for innovating in the classroom.

However, the reviewed studies (e.g. Carmichael *et al.*, 1985; Hoyles, Noss and Sutherland, 1991) did lend some support to the view that a Logo in-service course that engages the attention of participating teachers as demonstrating a 'new' teaching and learning of mathematics might be worthwhile for advancement (even if the opportunities to bring about change in the classroom are limited). In particular, Hoyles, Noss and Sutherland's (1991) study appears to provide a most suitable model in designing an in-service course for primary teachers within the scope of the present research. Indeed, the *Microworlds* course (Hoyles, Noss and Sutherland, 1991) suggests a paradigm for studying and changing teachers' attitudes that takes fully into account the perspectives and sensibilities of the course participants in different settings (the course setting and the classroom), considers them as responsible professionals and calls them to take active participation, and has a specific focus on the teaching and learning of mathematics.

CHAPTER 3

The way forward

(Overview of the research)

This chapter describes the methodology used in the pursuit of the study goals. The chapter is structured into three inter-related parts. The first provides the overall framework for thinking about how to carry out the study. It deals with the orienting principles drawn from the literature reviewed and that hopefully will lead towards a new understanding of teachers' attitudes towards mathematics and its teaching. It also identifies the major sets of variables related to the phenomena under investigation and integrates them into a conceptual framework that guided the research. The second part concerns the strategies used to undertake the study. It includes the research design and addresses some fundamental methodological issues concerning the undertaking of the research. In the last section, I reflect back on the theoretical considerations and the research design to approach the study of teachers' attitudes and attitude change, and I briefly describe each of the two sub-studies which integrate the research.

TOWARDS A NEW UNDERSTANDING OF PRIMARY TEACHERS' ATTITUDES TO MATHEMATICS AND MATHEMATICS TEACHING

The analysis of the literature reviewed in the previous chapter has pointed to several limitations of studies of teachers' attitudes towards mathematics and mathematics teaching, and attitude change. One of the main deficiencies of existing research is the lack of an explicit theoretical framework in which the study of teachers' attitudes might be located. Another related research gap is the general lack of knowledge on the factors that affect teachers' attitudes. This issue is perhaps one of the least understood in the field and probably one which is the most critical to the planning of attitude change. Moreover, very few studies have traced the study of attitude change by examining the dynamics of the change process, and in particular taking into consideration the perspectives of the teachers involved. The purpose of this section is to outline an agenda for this study which takes into consideration the existing research gaps in the field and which might contribute to advancing existing knowledge of teachers' attitudes towards mathematics and mathematics teaching, and attitude change.

Theoretical considerations

This sub-section presents three principles to be used as action guidelines in this study. They represent, in my opinion, the most basic considerations leading to a new understanding of teachers' attitudes towards mathematics and mathematics teaching, and attitude change.

Principle 1: Attitudes can be understood only as the history of attitudes

This principle argues that in order to understand the character of teachers' attitudes towards mathematics and mathematics teaching, it is necessary to consider how these attitudes were formed. The point here is that attitudes are learned and are continually evolving as a result of different experiences. Similar attitudes may have resulted from different experiences and vice-versa. Hence, it is relevant not only to recognise what teachers' attitudes are, but also to know why they hold such attitudes. It is not suggested that *all* the experiences contributing to teachers' attitudes should be brought to light, but that efforts should be made to uncover some of the factors that might explain those attitudes. In particular, it seems important to attempt to trace teachers' past experiences with mathematics as pupils.

Principle 2: Change can be understood only as the history of change

In the same way that attitudes can be understood only as the history of attitudes, the study of attitude change should not limit itself to acknowledging that change did or did not occur. For example, in attempting to document eventual changes in teachers' attitudes towards mathematics and mathematics teaching associated with a staff development programme, it is essential to try to understand the trajectories followed by the participating teachers. I am advocating, then, an approach to the study of attitude change that takes into account not only the outcomes of an intervention aimed at producing change, but also how and why change does or does not take place. I suggest in line with the model of attitude change proposed by Petty and Cacioppo (1986) that special attention should be given to the teachers' motives for joining the staff development programme, and in particular, whether or not they had already felt a need for change.

Principle 3: The main agent for educational change is reflection

The research literature on educational change is full of examples of "innovation without change". Olson (1980), for example, documents the dilemmas and problems that the teachers who were involved in a curriculum innovation project faced in trying to implement it. These teachers solved these dilemmas and problems by using familiar strategies and old methods and adapting them to the new curriculum. What was supposed to be new remained basically the same. Rather than blaming the teachers for this kind of situation, Olson criticises earlier approaches to educational change and proposes a perspective labelled as *reflexive*, according to

which "teachers have a key role to play because it is they who must find a way of making new ideas work" (Olson and Eaton, 1987, p. 193). In similar lines, Fullan (1982) points out that a major problem in educational change is that those who plan and decide on it, and those who are supposed to implement it often live in two different worlds. He then suggests that teachers should "be brought in contact with each other and with external resources in a focused way around a given change" (p. 128). Other authors (e.g. Zaltman, Florio and Sikorski, 1977) have also indicated that change in education is intended to be, but it is not always synonymous with improvement in education. Thus, a massive teacher resistance to an innovatory programme may simply mean that the programme was ill-defined and did not meet felt needs for improvement.

This third principle argues that the main agent for bringing about educational change is reflection, both teachers and educational researchers' reflection. It captures the spirit of Olson's (1985) reflexive principle of change, namely in that bringing teachers to come to know new ideas can stimulate them to try new ideas in their jobs, and act as a catalyst for promoting them to reflect upon their old attitudes and practices. This, in turn, can be the first step to change. But there is always a danger of thinking that it is easier to change others than changing ourselves. Thus, this third principle takes further Olson's reflexive principle by pointing out that those interested in promoting change should also reflect upon their attitudes and practices to bring about change. The point here is related to that brought by Fullan (1982) in putting forward the gap existing between teachers and educational researchers. It may be desirable that teachers change their attitudes and practices, and expected that they can profit from the new ideas brought by educational researchers. However, it should not be forgotten that teachers are in a knowledgeable practical position and that they have things to say. The process is no different from that of teaching/learning mathematics in the classroom. It is quite reasonable to accept that children can learn from their teachers, but it should not be assumed that children are empty vessels to be filled in with knowledge and that they have nothing to offer.

Conceptual framework

Given the relative lack of knowledge about primary teachers' attitudes towards mathematics and mathematics teaching, it was considered better to treat the present research in an exploratory, inductive way. This is not to say that I initiated this investigation with a completely 'blank mind'. The review undertaken, in effect, has suggested a fair number of variables related to the topic under scrutiny amenable to empirical study, that when integrated could inform a sort of map-making for the present research. The purpose of this sub-section is to outline a conceptual framework that posits in a broad way different sets of variables that were considered relevant to investigate within this study (see Figure 3.1).

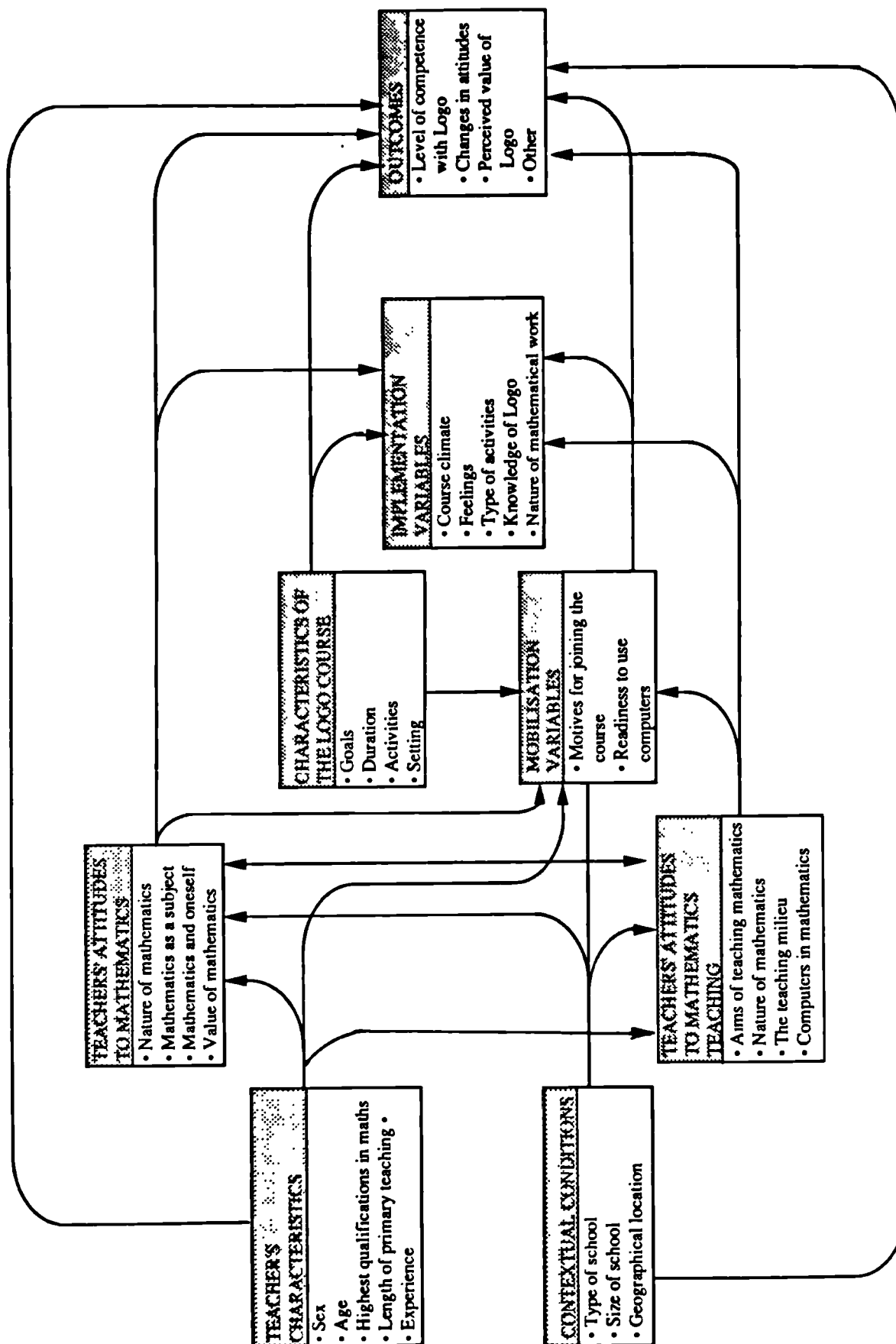


Figure 3.1: The Study Conceptual Framework

The framework includes eight sets of variables:

- *Teachers' characteristics*
- *Contextual conditions*
- *Teachers' attitudes towards mathematics*
- *Teachers' attitudes towards mathematics teaching*
- *Logo course characteristics*
- *Mobilisation variables*
- *Implementation variables*
- *Outcomes*

The first two categories, teachers' characteristics and contextual conditions, represent variables that are thought to influence teachers' attitudes towards mathematics and mathematics teaching. These variables are relatively invariant throughout the study, but differ across the participants in the study. Teachers' characteristics include biographical variables such as age and sex, as well as variables concerning their academic and professional experiences such as highest qualifications in mathematics and length of primary teaching experience. Contextual conditions refer to the local organisation of the teachers' schools, the characteristics of the community surrounding the school, and the country's broad features.

The third and fourth sets of variables corresponds to the main constructs examined in the study: (a) teachers' attitudes towards mathematics; and (b) teachers' attitudes towards mathematics teaching. They also differ across the participants, but unlike the two previous sets of variables, they are expected to be influenced to some degree throughout the study, namely as a result of the participants' involvement with the Logo course. For the purpose of the research, I conceptualised teachers' attitudes towards mathematics in terms of four main areas:

- *Nature of mathematics* (teachers' views about mathematics);
- *Mathematics as a subject* (teachers' views of the subject taught in school);
- *Mathematics and oneself* (the way teachers feel personally in dealing with mathematics in terms of both enjoyment and confidence); and
- *Value of mathematics* (teachers' perceptions about the importance and usefulness of mathematics in society).

Teachers' attitudes towards the teaching of mathematics were captured into four separate but interrelated categories:

- *Aims of teaching mathematics* (teachers' opinions about the aims of teaching mathematics in primary school);
- *Nature of mathematics learning* (teachers' theoretical principles about how the learning of mathematics by the individual child best takes place);
- *The teaching milieu* (teachers' intentions of behaviour concerning the classroom atmosphere in relation to pupils' mathematical learning); and
- *Role of computers in mathematics lessons* (teachers' opinions about the role of computers in children's mathematical learning).

A thorough description of these attitudinal areas and the rationale to consider them are included in Chapter 4.

The fifth class of variables are associated with the characteristics of the Logo course. These, too, will be discussed in detail in Chapter 4, and no more than a brief mention needs to be made here. In each country, the course consisted of 12 two-and-a-half hour sessions spread over a period of an academic term. The course was planned with the purpose of offering participating teachers an opportunity to teach and learn mathematics within a Logo environment. The most important consideration, however, is that it was framed in terms of providing a context for affecting teachers' attitudes towards mathematics and mathematics teaching. It should be mentioned, too, that the course though planned to be the same in the two countries, would take different forms. Moreover, it was not considered as an unchanging, pre determined sequence of activities.

Mobilisation variables, the sixth set of variables, include various aspects which are associated with the course participants' decision to join the Logo course. To my knowledge, very few studies have focused on why and how teachers come to make this kind of decisions. Yet, according to Petty and Cacioppo's (1986) 'Elaboration Likelihood Model' described in the previous chapter, these aspects are considered the first step to the central route to attitude change. In line with this model, two variables that seem important to consider in relation to the participants' mobilisation are their motives for joining the course and their state of readiness for using computers and Logo. The mobilisation variables are likely to be influenced by the five previous sets of variables. For example, someone who is sensitive to mathematics is likely to be interested in an in-service that deals with mathematics. The term *mobilisation* was used because it connotes a flow of events that neither begin nor end with the decision to join the Logo course. That is, mobilisation variables may well exist prior and continue throughout the Logo course.

The participating teachers were not seen as mere recipients of the Logo course. Interactions with the course would differ from one participant to another, being influenced by (and influencing) some of the earlier variables. From this standpoint, it is important to consider a set of *implementation* variables concerning the dynamics and transformations associated with the extent of interaction possible between the participants and the Logo course. Like in the previous case, there is no clear basis for deciding *a priori* what the variables should be. But the following variables might be salient and therefore worthwhile for investigation: (a) feelings (e.g. frustration, contentment); (b) level of willingness to be involved with the experience (e.g. commitment, involvement); and (c) type of activities (e.g. self-initiated, implementation of Logo in classroom). Moreover, attention should also be paid to the participants' development of skills with computers and Logo. Finally, the participants' interactions with Logo should be examined from a mathematical perspective. This refers to the possible isomorphism existing between Logo and mathematical work, and would be roughly estimated from, for example, the kind of mathematical knowledge the participants used (e.g. mechanical versus relational), and the nature of mathematical activities (e.g. facts/skills, looking for patterns, conjecturing).

The last set of variables correspond to the outcomes of the teachers' participation in the Logo course. These are related to the course objectives and are essentially of two kinds. The first concerns the participants' level of competency in using the computer and Logo. The second, and most important, set of outcomes concentrates on the possible changes in the participants' attitudes towards mathematics and towards mathematics teaching, and subsidiarily in their attitudes towards computers. These outcomes are thought to be influenced by all the previous sets of variables

The framework was to be used as a flexible tool which could be modified in the course of the research. This meant, in particular, that some of the variables which were initially considered relevant were dropped because either they were difficult to measure or they were of minor importance compared with others. On the other hand, some factors which had not been initially integrated into the guiding framework came to be incorporated as the field work was carried out, because they were perceived to help understand the phenomena under investigation. For example, throughout the course sessions it became evident that the relationship of cooperation between participating teachers, and in particular between working-partners at the computer, was an important factor to take into account when analysing the activities they were engaged in. The challenge was to identify throughout the study those key factors amenable to assessment which appeared to account for the variability of the participating teachers' attitudes and interactions with the course.

A TWO-COUNTRY 'ZOOM LENS' RESEARCH DESIGN

This section delves into the issues of planning and developing a design which is appropriate to meet the study's general goals. Before turning into these considerations let me restate here these goals as articulated at the beginning of the first chapter:

- to investigate primary teachers' attitudes towards mathematics and towards mathematics teaching, and as a subsidiary aim to examine factors that might account for these attitudes;
- to examine ways in which primary teachers' attitudes towards mathematics and mathematics teaching along with other factors influence their participation in a Logo-based mathematics in-service course;
- to ascertain the degree to which primary teachers' attitudes towards mathematics and its teaching are influenced by their participation in a Logo-based mathematics in-service course.

The reader will probably agree that these goals are much more ambitious than those of most of the studies of teachers' attitudes towards mathematics and mathematics teaching that were reviewed in the previous chapter. How is it possible that a single study both survey the range of teachers' attitudes, and at the same time, bring into focus how teachers' attitudes influence and are influenced by their participation in an in-service course? As an answer to this question I developed a "zoom lens" (Loucks, Bauchner, Crandall, Schmidt and Eiseman, 1982) research design consisting of two (or three) inter-related stages, each of them attempting to illuminate all of those three issues.

Before proceeding with the description of the "zoom lens" feature of the research design, another important aspect is essential. As already stated in the first chapter, it was considered that knowledge in the area would be best furthered by undertaking a similar investigation in two markedly different countries, England and Portugal. Thus, the study consisted of two sets of pictures (one in England and the other in Portugal) which are brought together to understand better what is depicted in each of them.

The argument underlying the "zoom lens" characteristic of the design runs more or less like this. The understanding of how teachers' attitudes influence and are influenced by their participation in a staff development programme would not be possible without first examining

questions such as the nature of teachers' attitudes and factors that might account for them. This being the case, it was decided to start the investigation with a wide angle lens by undertaking a large sample survey of primary teachers' attitudes towards mathematics and mathematics teaching. This big picture would provide substantial help in focusing upon the attitudes of the two small groups of teachers (one in each country) who would attend the in-service Logo course. Focusing still further, so that the process of attitude change throughout the course might be examined in detail, in-depth case studies of four teachers (two in each country) were to be undertaken.

It should be noted that while the focus of the three lens research design was on the same topic (primary teachers' attitudes towards mathematics and its teaching), the three pictures were taken in each country at two different points in time and of two different populations. Thus, the research is probably better understood to consist of two qualitatively distinct sub-studies which grew out of a single broader framework. In spite of their interrelatedness, these two sub-studies still had a large degree of independence, and their findings are therefore presented separately in this thesis.

Methodological considerations

There are at least three major methodological problems which should be discussed before the design above may be considered an acceptable one. First, attention has to be given to issues affecting multi-country research in general. The second problem to be addressed is that of integrating the macro and micro dimensions. The last issue concerns my own stance in approaching educational reality.

Multi-country research issues

Whilst multi-country studies have the potential to bring insights to a phenomenon under investigation, they carry out with them some difficulties as well. One of the obvious problems is that of assuring equivalence of measures used in different countries. In their review of cross-country studies of attitudes, Davidson and Thomson (1980) referred to two main types of measure equivalence -- *functional* and *score* equivalence. The first concerns the equivalence of constructs that are being measured. That is, the attitude constructs examined should have the same meaning across the countries. The second one, *score* equivalence, refers to the comparability of 'psychometric' properties of the instruments used to measure the constructs. An evident source of non-equivalence is related to the translation of the measurement instruments. Multiple translations and back translations into the original language are basic procedures normally used to increase linguistic equivalence (Hulin, 1987).

Another problem affecting equivalence is that of the existence of stimuli which are either irrelevant or inappropriate for one of the target countries. In general, this problem is overcome by pre-testing the instruments with populations similar to the final samples. Added dimensions and complications are brought about, for example, by lack of comparability of sampling and data-collection procedures. Some authors have also called attention to the problems emerging with the interpretation of multi country data. Another trap of cross-country studies resides in that they may lead to attempts to consider them as results of a competition. This is well illustrated, for example, in the emphasis put on and inferences drawn from the comparisons between the performances of pupils in Japan and in other countries in the recent Second International Study of Achievement in Mathematics (Noah, 1984).

Integrating macro and micro dimensions

All the studies of teachers' attitudes reviewed in the previous chapter remained at either a micro or a macro level of analysis. Here, support is found for the idea that research that takes into account both macro and micro dimensions is better able to capture the social reality than one that stands at one of the extremes of the polarity. A case for such a middle position is made, for example, by Silverman (1985). He says that "analysis can never begin by treating individuals as the primary point of reference" (p. 89), for individuals are embedded in a social context from which they cannot be dissociated. A similar point of view was recently put forward by Tabachnick (1989) in referring to research in teacher education. This author suggests that large-scale studies offer background information useful to understand face-to-face investigations, whereas the study in depth of a few cases helps to "balance, correct and enrich the more abstract analysis of large sample studies" (p. 158).

The integration of micro and macro dimensions seems to be particularly important in cross-cultural research. As Berry (1980) put it: "both emics and etics are essential levels of analysis in cross-cultural psychology: without etics, comparisons lack a frame; without emics, comparisons lack meat" (p. 13). *Emics* and *etics* are two terms derived from linguistics which have been applied in cross-cultural studies. Their meanings correspond to the two perspectives from which phenomena can be observed in cross-cultural research: one from within a specific culture (*emics*), and the other from an outside position involving more than one culture (*etics*). Now, it is evident that one cannot come to have both an *emic* and *etic* perspectives of a phenomenon by examining only a few cases. For such an examination would necessarily not allow for generalisations, making it difficult to ascertain which differences and similarities among individuals are idiosyncratic and which ones may be accounted for cultural variables.

Approaching educational reality

The problem of how to approach educational reality has led to endless debates, and I do not propose to enter it. However, this is a problem that every educational researcher has to face and it is good for the reader that in writing about my work I state my own stance. To assume a well-defined position may be, however, difficult if possible for someone like myself approaching the educational reality as a researcher by the first time.

Nonetheless, just as the literature reviewed in the previous chapter offered guidelines to understand some aspects of the phenomena under scrutiny, so too it was useful to establish parameters for choosing a research paradigm to study those phenomena or rather for deciding which research paradigms not to choose. I prefer, then, to state my standpoint in this study in terms of what I thought approaching educational reality should *not* be. Educational research can be neither an uncontaminated language of fact and objectivity nor a mere interpretative account of contexts and actions of participants in educational settings. But if I have to state clearly my position, I would say that it is similar to that echoed by Bruner (1986) in referring to the language of education: "It must express stance and must invite counter-stance and in the process leave space for reflection, for metacognition" (p. 129).

THE STUDY

As already stated, this study consisted of two inter-related but independent sub-studies. In this section, I will describe each sub-study briefly. Each description follows a fairly typical format: (a) the study specific objectives and methodology; (b) the nature of data collected; (c) the participants in the study; (d) the procedures involved in the fieldwork; and (e) an overview of data analysis.

Sub-Study 1: A Survey of Primary Teachers' Attitudes towards Mathematics and its Teaching

This sub-study was envisaged in order to act as a guide to the second sub-study. It was intended (a) to serve as input into the thinking about the attitudes towards mathematics and mathematics teaching of primary teachers both in England and Portugal, and (b) to serve as a baseline against which to assess change in primary teachers' attitudes towards mathematics and mathematics teaching during their participation in a Logo-based mathematics in-service course.

Objectives and method

The specific objectives of this sub-study were:

- *To assess primary teachers' attitudes towards mathematics and towards mathematics teaching in terms of various selected areas, and subsidiarily to identify relationships between various background characteristics of primary teachers, and their attitudes towards mathematics and mathematics teaching.*
- *To reveal differences and similarities between the attitudes towards mathematics and mathematics teaching of Portuguese primary teachers and those of English ones;*
- *To offer some implications of the findings to assist in the interpretation of the attitudes towards mathematics and mathematics teaching of the primary teachers participating in the second sub-study.*

This sub-study first essential was that it should be comprehensive in two ways. First, given the exploratory nature of the study, it was to be comprehensive in its coverage of the range of issues to investigate. Second, it was also to be comprehensive in its coverage of the range of audience. This, in turn, suggested that from the variety of approaches existing for assessing people's attitudes, a survey mode of data collection involving a self-administered attitude questionnaire was appropriate.

Nature of the data collected

In the absence of existing instruments for the kind of issues to be investigated, it was necessary to develop an attitude questionnaire specifically for the purpose of the research. The procedures undertaken to develop the questionnaire are described in some detail in Chapter 4, and the actual questionnaires used in the sub-study (in England and in Portugal) are presented in Appendix A.1 and Appendix A.2. Here a short description of the questionnaire will suffice. The questionnaire which was finally developed consisted of three sections. The first two sections included 40 items designed to assess teachers' attitudes on the eight attitudinal areas briefly described in an earlier section. The last section of the questionnaire sought for factual information about teachers' background variables, and included thirteen questions, both of a closed and open-ended nature.

With the exception of the items exploring teachers' opinions about the aims of teaching mathematics, all the remaining items were selected in order to form different Likert type attitude scales. Each attitudinal scale consisted of four to six items to which the teachers responded on a

5-point scale by indicating *strongly agree, agree, uncertain, disagree, or strongly disagree*. It is possible to argue that the number of items per scale is relatively small. In this regard, it should be noted that the initial pool of items was considerably larger, but that several of these items came to be discarded in the course of the pilot work. Moreover, it was considered that the questionnaire should not be too long. Indeed, the literature in the field suggests that with such an instrument, the longer it is, the greater the problem in getting people to answer to it (truly a case of 'small is beautiful'). In Chapter 4, reference will be also made to the literature in the field of attitude assessment that points to a relatively small number of aspects to characterise people's attitudes toward an object. Another point to be born in mind is that the items were not only to be grouped to form different attitudinal scales, but they were also chosen to provide *per se* useful information about teachers' attitudes.

The target populations

The samples for the main quantitative survey comprised all primary teachers of the Viseu district, in Portugal, and all the primary teachers employed by the Suffolk County Council, in England. The main justification for the selection of the sample in Portugal was that the Viseu district constituted the pioneering one in adopting reforms at the level of primary teachers training with the creation of the ESE of Viseu, thus probably being at the time of the survey the only district having a group of primary teachers who had received a new form of initial training. (Although this was not an objective of the research, it would be interesting to know whether the new kind of training would influence teachers' attitudes). Coupled with this aspect was the fact that that population was the one to which I could have easier access (at the time of the survey I was a member of the staff of the ESE of Viseu).

Several reasons determined the choice of the Suffolk County Council in England. First, Suffolk may be said relatively similar to that of Viseu in terms of the urban/rural divide. Second, the local educational authorities were developing a comprehensive advisory service in mathematics and computers education, and were interested in knowing the results of their efforts. Finally, they were keen to accepting my request for cooperation in the administration of the survey, namely by providing the material means (human and monetary) needed to undertake it.

No sampling procedures took place within those two populations. This was so for two main reasons. Firstly, data about the two populations on the variables of interest were not easily available to make either random or stratified sampling possible. Secondly, no other studies involving these populations were found to make it possible to estimate their level of interest and participation and suggest the sample size required.

In the end, 588 primary teachers in England and 1680 primary teachers in Portugal took part in the survey, corresponding respectively to about 20% and 84% of the populations surveyed. This striking difference in the response rates in the two countries is an interesting finding in itself and will be further considered in Chapter 5. Here, it should be pointed out that the percentage of English respondents above mentioned may be an underestimation of the 'true' response rate. Official registration figures include the number of teachers in all school types covering the primary age range. This means, in particular, that the official figures include all middle school teachers (9 to 13). For the purpose of the survey, only those middle school teachers of pupils aged 9 to 11 should have been asked to participate in the study. Therefore, the number of teachers in middle schools to whom the questionnaire was distributed may be smaller than the corresponding number of the teachers in these schools, although it is not possible to state by how much.

Administration of the survey

The survey was administered in England between November 1987, and January 1988, and in Portugal between February 1988 and March 1988. In both countries, the local education authorities provided the material means (human and monetary) needed to undertake the survey, and were also responsible for the organisational requirements for the questionnaire administration. The basic procedure used for the questionnaire administration was that of sending them off to the headteachers of all primary schools, who in turn were to distribute them to all primary teachers in their schools. The respondents could opt for returning the questionnaires by either mailing (directly or through their headteachers) to myself or to the local education authorities. In this regard, an interesting difference between the procedures used by the respondents in the two countries should be noted. In Portugal, the great majority of the questionnaires were returned to the local departments of education which, in turn, mailed them to me. In England, in contrast, only a small percentage of respondents opted for doing so. In fact, most of the questionnaires were sent to me by the headteachers. Alternatively the English respondents mailed the questionnaires directly to myself.

Another issue regarding the data collection should be mentioned. After the questionnaires have been distributed, the low response rate in England was soon realised. Bearing this fact in mind, two follow-up letters were sent to the prospective respondents calling for their participation. In Portugal, in contrast, given the quick and massive rate of participation, such a practice was judged unnecessary.

Overview of the data analysis

The two sweeps of the attitude survey, the one carried out in England and the one carried out in Portugal, yielded a very large amount of data which were coded and transferred to two

different data computer files. In coding the answers to the attitudinal items, two problems emerged: (1) missing information due to the failure of the respondents to circle one of the numbers; (2) cases in which the respondents circled two numbers. At first, unique signal codes were used for such cases. Subsequently, these cases were reconsidered in the light of rules established in order to produce consistently plausible codes. For example, when the respondents circled two numbers corresponding to the two different levels of agreement (or disagreement), it was decided to code the answer as an "agree" (or "disagree") response. When the respondents circled numbers expressing conflicting opinions (agreement and disagreement) then their positions were qualified as uncertain and their answers coded accordingly.

The data were subsequently analysed separately by making use of the Statistical Package for the Social Sciences (SPSSX), and afterwards compared. The three areas covered by the questionnaire -- attitudes towards mathematics, attitudes towards mathematics teaching and background information -- produced a total of about 70 variables. (As a matter of illustration, the list of variables, including the description of the variables together with the variables labels, brief coding details and column identification associated with the English data file set is presented in Appendix B.1).

The quantitative analysis was undertaken in a similar style to that proposed by Glaser and Strauss (1967). That is, statistics were used in an iterative and exploratory way which permitted refinement and clarification of the concepts and measures, rather than testing hypotheses and theoretical models, and making accurate verifications. First, descriptive analyses were run on all variables (the individual attitudinal items and the variables related to the respondents' personal characteristics) to make sense of data. After careful consideration of this first round of analyses, some of the variables were dropped (e.g. age group taught) and others were recoded (e.g. academic qualifications). In addition, some derived variables were created.

The next step was to run a second round of descriptive analyses for each of the retained and created variables. These included in particular the analysis of the respondents' answers to the attitudinal items. This consisted of the analysis of the distributions of actual frequencies and percentages of respondents' answers to the individual items in terms of the five alternative options (from strongly disagree to strongly agree). Missing answers and written comments to individual items were also noted. This was considered specially important in assessing the validity of the items.

The respondents' attitudes were further assessed by making use of a procedure similar to that proposed by Likert (1967) -- the scores (the actual scores from one to five, or their

complements to five) corresponding to the items included in each attitudinal scale were summed to provide a single summary score. Analysis of the summary scores consisted of frequency charts, and the commonly-used measures of tendency (mean, median, mode) and of spread (minimum, maximum, and standard deviation). This second method presents two major advantages. First, it provides a quick picture of the respondents' attitudes concerning the various dimensions considered. Second, it makes less cumbersome the task of detecting patterns of the respondents' attitudes in terms of their background characteristics. However, this form of analysis has also some pitfalls as well. One of the major shortcomings is related to the extent to which scores that were used to give a relative rank ordering of preference can be handled as if they were of interval nature. In this regard, it may be instructive to quote here Gardner (1975) in discussing the issue: "The distinction between ordinal and interval scales is not sharp. Many summated scales yield scores that although not of strictly of interval strength, are only mildly distorted versions of an interval scale" (p. 55). Another shortcoming associated with this type of analysis concerns the unidimensionality (or rather the lack of it) of the scales. Inter-items correlations were calculated in order to test whether the items included in a scale assessed the same attitude. Any item that did not covary with the other items in the scale was then to be rejected.

Items originally included in a scale were also discarded in cases in which the number of respondents who either endorsed (agreed or strongly agreed with) or rejected (disagreed or strongly disagreed with) such items corresponded to a percentage higher than 80%. It was considered that items in such conditions would not contribute to discriminate among the respondents within the same country. When the number of retained items contributing to a scale fell below three (Piazza, 1980/81), the respondents' answers were analysed only at item level.

For the purpose of cross-country comparison, the two data sets from the two countries were analysed separately and only afterwards were the results compared. In comparing the respondents' answers to the individual items, it was borne in mind that they cannot be taken as infallible yardsticks and that cultural differences are of major significance in interpreting the answers to them. Thus, in order to maximise comparability of the data across the two countries, the initial 5-point scale was collapsed into a 3-point scale (by concatenating the categories "strongly agree" and "agree" on the one hand, and the categories "strongly disagree" and "disagree" on the other hand). The chi-square test was then used to assess the extent to which the distributions in the two populations were significantly different ($p < .001$). The comparison between the teachers' opinions about the aims of teaching mathematics was performed both at the item level (considering the concatenated 3-point scale) and taking into

account the relative rank order of the aims within each country (considering the initial 5-point scale) .

In turn, in comparing the attitudinal scale summary scores, I resisted the temptation of interpreting different means of attitude scale scores in the two countries as necessarily meaning different attitudes. Thus, a simple form of profile analysis was carried out (Morrison, 1978) aimed at highlighting whether or not the profiles of mean scores from the different attitude scales for the two populations were similar. In this regard, it should be mentioned that for the purpose of comparison of the means only those common items that were appropriate in both countries were considered for making up the summary scores. Since the items which were inappropriate to make part of a scale in one country, but were acceptable in the other, might be interpreted as expressions of a 'national' trend of opinion, they were judged to provide useful information under a cross-country perspective. In particular, it appeared important to identify those items which indicated a strong tendency of opinion in one country and promoted a diversity of opinions in the other country or even a strong opinion but with the reversed sense.

Following the descriptive analyses, bivariate analyses, largely cross-tabulations and correlations were also conducted. These bivariate analyses provided a means of establishing the likely pairwise relationships between the independent variables, and between the independent variables and the dependent ones. Finally, repeated multiple regression analysis techniques were used in order to attempting to explain the variability of the respondents' summary scores on the different attitudinal scales in terms of different independent variables. (Details related to the undertaking of the multiple regression analyses are presented in Appendix B.2). Finally, estimates were to be made of the extent to which the relationships between the teachers' attitudes, and between teachers' attitudes and their characteristics could generalise across the two countries. However, these latter comparisons remained largely to be done for reasons that will become clear in Chapter 5 which presents the results of the survey.

Sub-study 2: A Logo in-service course as a basis for changing primary teachers' attitudes towards mathematics and mathematics teaching

Because teachers' attitudes towards mathematics and mathematics teaching are acquired, they can be, at least theoretically, modified. This sub-study was designed to examine whether primary teachers' attitudes could be influenced throughout their participation in a Logo-based mathematics in-service course, and to explore factors that increase or decrease the likelihood that attitude change will occur.

The sub-study involved, first of all, the design and implementation of a Logo-based mathematics in-service course for primary teachers both in England and Portugal. This was the "curriculum development component" of the study, meant to use what is known about staff development programmes to design and implement an in-service course which would enable participating teachers to learn and teach with Logo, and at the same time could serve as a catalyst for changing their attitudes towards mathematics and mathematics teaching .

Objectives and method

The objectives of this sub-study were specifically:

- *To explore and describe the attitudes towards mathematics and mathematics teaching that the participating teachers held initially, as well as their motives for joining the Logo course.* The interest is in gaining further understanding of primary teachers' attitudes towards mathematics and mathematics teaching. Were these consistent with the findings of the first sub-study? How might the attitudes of the teachers who join staff development programmes be different from those of teachers who rarely feel motivated to do so? Moreover, examining the participants' motives for joining the course would form a solid basis for understanding the pursuit of the study objectives that follow.
- *To examine the extent to which and the ways in which the attitudes towards mathematics and mathematics teaching of the participating teachers that were recognisable at the beginning of the Logo course interacted with other factors throughout their participation in the course.* Here, the aim is to explore the web of factors that together with the participants' attitudes towards mathematics and mathematics teaching informed their approaches, practices, feelings and concerns throughout the course.
- *To investigate what kind of influences, if any, might the participating teachers' involvement with the Logo course have on their attitudes towards mathematics and mathematics teaching, and what factors may account for those influences.* Extending the previous objective, this one aims at identifying the characteristics of the participants whose attitudes seemed to be most influenced by their participation in the course, and how they were influenced by it.

This study can be described as a creative, developmental one; one which combines ethnographic methods and concepts (as described, for example, by Goetz and LeCompte, 1984) with principles akin to an action research paradigm (as specified, for instance, by Carr

and Kemmis, 1986). From an ethnographic point of view, the study examined the nature of the participating teachers' interactions in the setting of an in-service course (and to a lesser extent in their classrooms too). From an action research perspective, the study offered the participating teachers an opportunity to reflect upon and alter their attitudes and practices while they were integrally involved in the in-service course activities. Equally important from an action research standpoint is the fact that the study involved a spiral of steps, each step consisting of planning-acting-fact finding-reflecting. Having initiated the study with a loose theoretical framework and a few theoretical principles in mind, I used the fieldwork to interpret them and acting subsequently in accordance with what I would have learned from the experience. For example, only after the earlier course sessions, I came to realise that interrelationships between peers were an important factor accounting for the participants' interactions with the course. For example, as a result of contiguity and conditioning, the cues that communicated one participant's feelings were able to arouse corresponding emotions in the working peer. Consequently, at a later stage, I often asserted who was to be working with whom rather leaving it to the participants' choice.

Nature of the data collected

Four main different sources of data were used to assess the course participants' attitudes throughout this sub-study. The point of relying upon a variety of methods to assess teachers' attitudes was associated not only with the idea of overcoming the weaknesses of any of the methods and cross-checking results, but was also with the assumption that attitudes are reflected in different ways in different situations. The following is a brief description of the different methods used, as well as provides the timing of the data collection.

Semi-structured interviews

Participating teachers were interviewed twice, once before the course and then again after the course. Each of the interviews was of a semi-structured nature, relying on a set of common questions to be explored with each participant, but allowing enough room for probing and having the interviewees communicate their perspectives in their own way. The pre- and post-interviews protocols (for use with the English teachers) are presented in the Appendix A.3 and Appendix A.4, while the procedures used to develop them are described in Chapter 5. Embedded in the pre-interview were questions that ascertained the participants' academic and professional background, and their attitudes towards mathematics, mathematics teaching and computers (both in general, and in the setting of mathematics education). The pre-interviews were also used to assess the participants' motives for joining the course and their expectations about it. The post-interview aimed at capturing the outcomes of the Logo course, namely in terms of the changes in the participants' attitudes, their degree of satisfaction with the course, and the perceived value of Logo. All the interviews were tape-recorded and fully transcribed.

The main advantage of this qualitative approach was that a wide range of detailed information was elicited which afforded some insight into the course participants' attitudes and into why they reacted to the course as they did. Moreover, the interviews were in many cases a way of having the participants analyse and articulate their attitudes towards mathematics and mathematics teaching perhaps for the first time. This kind of reaction was echoed, for example, by one of the Portuguese participants who said this just at the end of the pre-interview: "You know, before I was interviewed I was feeling a little bit uneasy... Now, I feel that having talked to you was great... The questions you asked me made me reflect upon so many things...".

Attitude questionnaire

Before and after the course, and prior to being interviewed, all the course participants were administered the attitude questionnaire which had been used during the first sub-study. The data derived from the self-administered questionnaire provided a measure of the participants' attitudes and of their response to the course which complemented the more interpretative data derived from the interviews, thus offering results that allowed for more objective comparison between the participants' attitudes and changes in them. In addition, the participants' responses to the questionnaire before the course started furnished data that easily lent themselves to assessing the extent to which the participating teachers were comparable to the populations surveyed in the first sub-study.

Participant observation

It has been argued that working with Logo may be seen both as a mathematical activity in itself and as a means of exploring mathematical ideas. Moreover, the point has been made that people's attitudes are to a certain extent reflected in their practices, and that it is through their practices that they are evolving continually. Hence, the participants' attitudes towards mathematics (and to a lesser extent their attitudes towards mathematics teaching) and variations in them would be mirrored in their interactions with the Logo course. As the tutor of the Logo course, I thought that I could act as a participant observer as well, thus having the opportunity to observe and record their activities and reactions throughout the course sessions. This approach was in line with Ostrom's (1989) recommendation that researchers should "devise ways of examining attitudinal thoughts in settings in which they naturally occur". However, I underestimated the difficulties inherent to the roles of course tutor and observer. To move to a position of observer while yielding the course tutor role may require more experience than I had. Therefore, although during each session I did take some field notes, these were scarce on the whole. Thus, my concern was that of establishing the habit of completing the field notes as soon as possible, and of reflection upon the sessions. The process became, then, more a

method of data analysis than of data collection, though at this stage there was no attempt to categorise data.

Dribble files

The computer dribble files, permanent computer records of the participants' work with the computer saved in disks, provided accurate information of the Logo work produced and of the strategies used in response to the course activities. These provided insights into their understanding of what a mathematical task is and of their underlying beliefs about mathematics. The use of dribble files made it possible to compare different parts of the Logo work of a course participant throughout the course sessions with a considerable degree of objectivity, as well as allowed for comparison across participants. In other words, it was possible to notice how different participants coped with a given task, and to see how the same participant responded to different tasks throughout the course sessions. In addition, the dribble files were used in connection with the field notes in order to gain a more accurate impression of the sessions.

Other data sources

The group discussions that took place during the course sessions and the visits that I undertook to the participants classrooms, which were intended primarily to serve other purposes, were also used to provide information about the participants' attitudes towards mathematics and mathematics teaching.

The target populations

The profile of the target participants was determined by two criteria established prior to their recruitment. Firstly, they were to have very little or no experience at all with Logo. This was based on the need to recruit fairly homogeneous groups of teachers with regard to their knowledge of Logo. In addition, this would ensure relative comparability between the participants in the two countries. The second criterion was that the prospective participants would be willing to implement Logo in their classrooms as part of the course requirements. In fact, it was felt that if the participating teachers would have to have the sort of experience that would help them to see how the innovation could work with pupils (Guskey, 1985). This criterion, in turn, meant that preference to enrol the course was given to prospective participants who could have access to computers in their classrooms. Moreover, it was felt that in order to understand the participants' attitudes and patterns of interaction with the course in detail, it would be useful to recruit only a small sample of teachers (between ten and fourteen).

In Portugal, the recruitment of the participants was made in collaboration with the MINERVA project by advertising it in its premises in the ESE of Oporto. In England, the participants were

recruited by advertising the course in *The Times Educational Supplement* and in Local Education Authorities newsletters. In the event, twelve Portuguese primary teachers from five schools from the Oporto area and nine English primary teachers from nine schools in London volunteered to join the course (two teachers in Portugal and two teachers in England ended up by withdrawing from the course after a couple of sessions, and no more reference will be made to them in what follows).

It is worth noting that the recruitment of participants in England was particularly difficult. In Portugal, in contrast, the course was oversubscribed. This fact, one that constitutes in itself an interesting finding under a cross-country perspective, will be further discussed in Chapter 6, together with other study findings. Chapter 6 also provides more information about the characteristics of the teachers participating in this sub-study.

Fieldwork

In both countries, the Logo in-service course consisted of twelve two and a half to three hours evening sessions which were spread unevenly over the duration of one academic term. The course theoretical orientation and details corresponding to the course design and implementation are described in Chapter 4. Here, it will suffice to say that the course was run in Portugal during the Summer term of the 1987/88 academic year and was organised in cooperation with the two centres of the MINERVA project in Oporto, and in England during the Autumn term of the 1988/89 academic year and was organised in cooperation with the Department of Mathematics, Statistics and Computing of the Institute of Education, University of London.

Overview of the data analysis

As Patton (1980) contends in using triangulation one can "guard against the accusation that a study's findings are simply an artifact of a single method, a single data source, or a single investigator's bias" (Patton, 1980, p. 332), but one is also left with the arduous task of analysing a voluminous quantity of data and integrating in a single picture often conflicting findings resulting from different methods, sources and investigators. The demands of carrying out qualitative analysis are not small either. In my efforts to attempting to draw 'valid meaning' from the considerable amount of the data collected, I followed an analytic approach based on the suggestions of Miles and Huberman (1984). The following provides an overview of the processes involved in such an endeavour.

Analysing the interviews

The first step in analysing the pre- and post-interviews (which had been fully transcribed) was that of collapsing the interview data down to manageable proportions. The starting point for

this task was that of creating three summary sheets (corresponding to the three major areas being investigated: attitudes towards mathematics, attitudes towards mathematics teaching, and attitudes towards computers) for each participant and for each interview. These sheets included a number of broad categories previously developed. For the pre-interview, for example, these categories consisted of all the attitudinal areas considered for the purpose of the first sub-study (with the exception of the attitudinal area of "value of mathematics"), plus two categories related to the participants' attitudes towards computers (personal feelings towards computers and attitudes towards the use of computers in education, in general). Extracts of the interviews relevant in terms of those categories were wrote down on the summary sheets. Other interview extracts which were considered relevant but that would not fit into those categories were included under the heading of "other" category. (An example of such summary sheets for the pre-interview conducted with one of the course participants is presented in Appendix B.3). In order to increase the validity and reliability of the summary/coding process, I reviewed the interview transcripts several times.

Based on these summaries, a new category system was created by noting salient aspects which occurred across a large number of respondents. The next step was that of generating three cross-participant matrices corresponding to the three major areas being investigated. These meta-matrices were used to assemble data from each of the participants, derived from both pre- and post-interviews, reflecting their viewpoints regarding the created attitudinal sub-categories. (As a matter of illustration the meta-matrix corresponding to the participants' attitudes towards mathematics teaching is provided in Appendix B.4). In addition to facilitating the identification of patterns of similarities and differences across the participants, these charts provided a rough picture of attitude change for each participant. These summary charts also offered a quick and useful reference to the participants' attitudes, but the actual transcripts were always accessible to interpretation and reinterpretation, as well as to use as references for identifying and quoting particularly representative remarks.

Analysing the questionnaires

The analysis of the course participants' answers to the attitudes questionnaire (prior to the course) followed a procedure similar to that used in the first sub-study. The data from the two groups of participants were transferred to two coding sheets first and to two computer data files afterwards, and were analysed separately. A form of profile analysis (Morrison, 1978) was carried out aimed at highlighting whether or not the profiles of mean scores from the different attitude scales for the course participants were similar to those of the populations surveyed in the first sub-study. The comparison of the opinions about the aims of teaching mathematics was carried out at item level taking into account the ranking order of the different aims. In addition, the frequencies (and percentages) of answers to the individual items judged to

represent 'national' trends were noted in order to assess the extent to which the course participants as a group followed those trends.

The analysis of the post-questionnaires aimed at examining variations in the individual participants' attitudes. Like in the previous case, the data were transferred to coding sheets and computer data files, but attention was paid to the answers of the participants to the individual attitudinal answers, as well as to their summary scores in the different attitude scales (rather than to the frequencies and mean scores corresponding to the whole group). Special emphasis was given to the answers to the individual items which corresponded to substantial shifts of opinion, for example, from endorsement to rejection (see Appendix B.5).

Interaction profiles

A key objective of the study was to examine the ways in which the participants' attitudes influenced and were influenced by their participation in the course. In order to meet this goal, it was necessary to map the participants' interactions with the course activities in a systematic manner, one which would allow for both illuminating the history of each participant throughout the course and making comparisons across participants. To this end, an *interaction profile* was created for each participant. (Again, as a matter of illustration, an example of an interaction profile for one of the course participants is provided in Appendix B.6)

The interaction profiles were derived from data collected by means of the dribble files and field notes. The first step towards creating a participant's interaction profiles was that of running and analysing the participant's dribble files, and transforming the Logo work records into descriptions of the character of this work and the strategies used. This provided a sense of the nature of the participants' Logo activity, and a suggestion of possible categories to analyse their work. Once all the dribble files for a single participant were analysed, a second-level analysis took place. This consisted of putting together the data provided by the dribble files analysis and field notes for each participant for each of the twelve course sessions. The basic unit of analysis was still the participant's work during a particular session, but this work was analysed in terms of common categories and components across the sessions. These components and characteristics were qualitative in nature. They included, for example, the kinds of activities a participant was engaged in one particular session, with whom he/she was working, his/her level of involvement with the work, the Logo programming features he/she was using, and the nature of mathematical activity associated with the Logo work.

At the final level of analysis, an attempt was made to build meta-matrices which provided a reasonable picture of the character of the Logo and mathematical work for all participants and for all sessions, but I ended up displaying information about only the first six sessions (see

Appendix B.7 and Appendix B.8). Indeed, at that stage clear patterns of work seemed to emerge enabling me to distinguish between the participants' interactions with the course, both within the same country and cross countries. At this stage, then, it was possible to shift attention from the characteristics of the work of the whole group of participants to that of the contrasting cases of four teachers (two in each country) who seemed to have reacted quite differently to the course.

Putting it all together

The research objectives involved trying to understand the reciprocal interactions between the participants' attitudes and the course activities, and therefore more than the mere description of what happened. It was, then, necessary to speculate about why those interactions happened. In order to provide a holistic picture of what happened and why, efforts were made to mould a story for each participant, trying to integrate all data collected related to that given participant. The participants' answers to the pre-interviews together with their answers to the attitude questionnaire before the course started were used to make sense of their interactions with the course, and at the same time these interactions were used to understand their attitudes. The participants' interactions were then used to explain possible changes in their attitudes. The analytic process used was similar to the 'constant comparative method' suggested by Glaser and Strauss (1967). The discovery of relationships was almost simultaneously inductive and deductive. Data from the individual participants were used to generate theory, and this was in turn used to write the story of a particular participant. That is, the initially written participants' case stories provided a preliminary knowing of each participant. The knowing of all the stories could then be used to interpret better the story of a particular participant. The iterative process was a demanding and exciting one to the extent to which successive refinements led in many cases to new interpretations. It is hoped that the process was long enough to promote a state of saturation of critical reflection upon the data and therefore to yield to plausible theory.

SUMMARY

This chapter began with a discussion of theoretical principles that should be considered in attempting a new understanding of teachers' attitudes towards mathematics and mathematics teaching, and attitude change. Then an array of variables that might contribute to this new understanding, and a loose framework describing these variables and their interrelationships was presented.

Based upon this theoretical discussion, the design for the present research was devised. A two-country 'zoom lens' design was envisaged and some methodological problems arising in

adopting such design were discussed. In spite of the possible shortcomings and difficulties associated with this research approach and design, a decision was taken of carrying out the enterprise. This consisted of undertaking two independent sub-studies: (1) an attitude survey; and (2) a developmental study of attitude change having for basis a Logo-based mathematics in-service course. These two sub-studies were to take place in England and Portugal, and the results to be interpreted from a vantage point gained by this cross-country perspective. The chapter ended with a brief discussion of these two sub-studies, specific objectives, methodologies and data analysis.

CHAPTER 4

Truth may seem, but cannot be

(Overview of the research tools)

This chapter focuses on the tools specifically developed for the purposes of this research to *mirror* primary teachers' attitudes towards mathematics and mathematics teaching. Let me digress first of all about the use of the expression *mirror* rather than *measure* or *assess* frequently utilised with similar sense. The purpose of avoiding these two latter words is to keep apart the idea of associating a fixed number or amount with an individual's attitude, something which is not compatible with my understanding of attitude. Lest the term *mirror* be mistaken for the idea of faithful or true description, let me emphasise my interpretation of the tools developed as no more than *distorted mirrors*. The metaphor of a *distorted mirror* stresses the point that through a particular mirror one sees certain facets of an individual's attitude, but one may see different images through a different mirror.

The issue of subjectivity in mirroring people's attitudes is also related to a second type of problems, one that was already addressed in Chapter 3 -- that of using a given mirror across different countries. To borrow Kuhn's (1970) words, among the few things that we know with assurance are: "That very different stimulus can produce the same sensations; that the same stimulus can produce very different sensations; and finally, that the route from stimulus to sensation is in part conditioned by education" (p. 193). Kuhn also suggests that these ambiguities tend to be minimised in cases of individuals who share education, language, experience and culture. Thus, one may speculate that the use of a given mirror to assess teachers' attitudes is a relatively reliable tool for the purpose of comparing teachers' attitudes within the same country, but poses some problems in a cross-country investigation.

These difficulties in *mirroring* people's attitudes led me to use Shakespeare's words as title of this chapter: *truth may seem, but cannot be*. However efforts to build 'perfect' *mirrors* of primary teachers' attitudes towards mathematics and mathematics teaching might be, the revealed image is always shaped by the form of the mirror and the culture.

This chapter is in three sections: (1) the attitude questionnaire; (2) the interviews; and (3) the Logo-based mathematics in-service course (onwards, this will be designed for short as the *Logo course*). It may be worth to say something about the reasons that led me to include here a section concerning the development of the Logo course. There are, in fact, several senses in which the course can be seen as sharing 'common' characteristics with the attitude questionnaire and the interviews. First, they are preliminaries to the fieldwork which were developed specifically for the purpose of this research by myself, thus reflecting my own perspectives. Second, the processes involved in their development are similar, corresponding to find by careful consideration and trial what seemed to be more effective among possible alternatives. Finally, although the main goal of the Logo course was attempting attitude change in the participating teachers, it was also regarded as a *mirror* of their attitudes.

THE ATTITUDE QUESTIONNAIRE

As stated in Chapter 3, an attitude questionnaire was developed for the specific purpose of this research. The questionnaire includes several attitude scales developed according a technique based on the traditional method of Likert (1967). This was recognised as the most suitable approach to employ with a large number of teachers across two countries. In this section, I will describe the structure of the questionnaire, as well as the procedures involved in the development of the Likert-type attitude scales.

Questionnaire structure

The developed questionnaire was six pages long including 40 attitudinal items and thirteen questions seeking for factual information. (As stated in Chapter 3, a copy of both the English and the Portuguese versions of the questionnaire is given in Appendix A.1 and Appendix A.2). As can be seen the questionnaire was in three sections. The first two sections covered the two general areas of interest of the present research: (a) teachers' attitudes towards mathematics; and (b) teachers' attitudes towards mathematics teaching. The third section aimed at collecting factual information on background and contextual variables concerning the teachers and their schools' characteristics. In order to avoid possible effects of tiredness and to maximise comparability between countries, this information was intended to be collected *after* respondents have answered the attitudinal questions.

Next, I will summarise each of these sections of the questionnaire. For each of the first two sections, I will characterise the specific attitudinal areas covered, its relevance for the study, and a brief description of the attitudinal scales. The *Background information* section specifies a

list of variables included, outlines what is known about their 'explanatory value', and provides some rationale for their inclusion.

Section 1: Attitudes towards mathematics

The attitudinal areas covered by this section were those alluded to in the conceptual framework presented in Chapter 3:

- *Nature of mathematics*
- *Mathematics as a subject*
- *Value of mathematics*
- *Mathematics and oneself.*

Nature of mathematics

This attitudinal area refers to teachers' views about characteristics of mathematical knowledge. Three features seem to be specially relevant from an educational perspective. Two of them are of epistemological nature: (a) mathematics is immutable -- a view akin to a *platonist* (Davis and Hersh, 1981) perspective; and (b) mathematics is a rigorous academic discipline about axioms, definitions and theorems -- a view akin to a *formalist* (Davis and Hersh, 1981) perspective. A third way in which mathematics is affected by an unfamiliar sentiment is through the assumption that mathematical knowledge is complex and mysterious, and that therefore its acquisition requires individuals who have a 'special' mind (a view that I label as *elitist*).

This area is especially relevant, in that teachers' views about mathematics are most likely to affect the nature of their interactions with the subject. Moreover, they may contribute to restrict greatly the access to new ideas in mathematics education. For example, the effect of a *platonist* view might reduce the likelihood of change in mathematics education by providing teachers and society in general with a sense that mathematics is timeless. The *formalist* view, in turn, may foster a feeling of certainty and authority, and therefore exert pressure against change as well. Finally, the *elitist* view of mathematics may lead to the idea that there is little point in engaging in efforts to innovate in mathematics education, since these are unlikely to produce any pupil-related outcomes.

The items in the *Nature of mathematics* scale revolved around the three views above described (e.g. Mathematics is consistent, certain and free of ambiguities) and their opposites. For the purposes of this study, endorsement of the former views corresponded to unfavourable opinions since they limit the possibility of attitude change, whereas their opposites were considered favourable ones.

Mathematics as a subject

The frequent use of the English expression *school mathematics* to refer to the mathematics taught in school is probably not an accident (interestingly enough, there is no equivalent term to *school mathematics* in the Portuguese language). The term emphasises that mathematics and school mathematics are distinct systems both important in their own rights. It renders unambiguous particular aspects of mathematics from other features by creating a new object of a different kind determined to a large extent by official guidelines.

As suggested in Chapter 2, the issue is of most interest to be investigated when it comes to understand teachers' views of mathematics and apparent ambivalences between their views and their instructional practices. The point is that for primary teachers the cognitive references that make up their views about mathematics are built up from extended experiences with the subject, both as learners and as teachers. That is, the teachers' subculture through the formal or informal sharing of ideas and practices about the subject that they have to teach is as important a determinant of their attitudes towards mathematics as their previous experiences with mathematics as pupils. It may be that through these different experiences, common traits between mathematics and school mathematics become clear and the differences become blurred. In this way, teachers would come to have an integrated view of mathematics. But it may well be that they lack a coherent and unifying view. This lack may be of critical importance to teachers' instructional practices in the classroom and their ultimate impact upon children's learning of mathematics.

Conceivably, the issue is most worthwhile to be examined from a cross-country perspective. Indeed, one may speculate that the presence or absence of opportunities for coming to know new directions in mathematics education is a significant factor in determining the extent of the gap between teachers' views about mathematics and about school mathematics.

That the two systems, mathematics and school mathematics, are different seems obvious. However, because this distinction tended to have been overlooked, there is not much basis on which to build the characterisation of school mathematics as opposed to mathematics. Therefore, I will specify a characterisation of school mathematics focusing upon aspects parallel to those used in relation to mathematics, namely unchangeability, certainty and elitism.

The *Mathematics as a subject* scale was designed to assess teachers' perceptions of the subject they have to teach in terms of those three features or their opposites (e.g. Maths is as creative a subject as art or music). As in the previous case, items reflecting views associated with unchangeability, certainty and elitism were considered as non-favourable and those expressing their opposites considered favourable ones.

Value of mathematics

This attitudinal area concerns the degree to which teachers perceive mathematics as a useful and important subject. The area is conceptualised in terms of several reasons why mathematics can be considered useful, and three come to my mind: usefulness in daily life, preparation of citizens for jobs and professions, development of the ability to think clearly.

The significance of the area lies, for example, in that teachers' perceptions of the utility of mathematics may exert a considerable influence on their decisions to avoid or pursue mathematical activities in the classroom. More significant perhaps are questions about the relationship between the value of mathematics in terms of its usefulness in today's world (which is very often alluded to), and the purely abstract way in which the subject tends to be taught in schools. Now, one of the factors that may account for this situation is historical. As Owen (1987) suggests, "throughout history there has been conflict between mathematics seen as a subject growing out of economic and social necessity and a view of mathematics that transcends mere practicality" (p. 17). Teachers' perceptions of the importance of mathematics as a consequence of the norms and values of different cultures seem plausible as well. Here, I point, for example, to the evidence provided by voices echoed by members of governments. In a recent communication, the Portuguese Ministry of Education (Cunha, 1990) stressed the importance of mathematics in terms of its "mental training" value. In turn, in England, several governmental voices have been heard about the importance of mathematics in terms of the economical development of the country. It would be interesting to know to what extent the governmental views are reflected in teachers' opinions about the issue.

The items for the *Value of mathematics* scale addressed teachers' perceptions about the usefulness and importance of mathematics in general, and in its relation to skills with specific issues, namely study of other subjects, everyday life situations and jobs (e.g. There is little need for more than very elementary maths in most jobs). High scores in the items included under this topic were attributed to the views that ascribed a great value to mathematics, as they are likely to be related to the extent to which teachers feel motivated to spend time and energy to attend staff development programs in mathematics.

Mathematics and oneself

This attitudinal area relates to the way teachers feel personally in dealing with mathematics in terms of both enjoyment and confidence. It was felt advantageous to consider teachers' beliefs about themselves in dealing with mathematics both in the present and in the past as pupils.

As many mathematics educators have proposed, affective variables play a very important part in the way people approach mathematical activities. That is, an individual's ability to engage in

mathematical activities is never more than a part of what is called *competence*. And this seems to be true for both pupils and adults. For example, Buxton (1981) provides evidence of adults experiencing panic when they were required to solve a mathematical problem and even before they had attempted to solve it. In the same vein, disliking mathematics may also reduce the initiative and time to engage in mathematical activities. It follows from this view that in creating mathematical teaching/learning experiences for teachers, it is important to know about their feelings in dealing with mathematics to explain and describe reactions that may occur in engaging in those experiences.

The purpose of attempting to assess teachers' feelings as pupils is twofold. First, as already stated the study of people's attitudes might be made more meaningful if one were to adopt an 'historical' perspective. This would serve to illuminate and help better understand people's feelings in the present. Second, there might be some teachers who refuse to admit that they feel uneasy and/or unhappy in dealing with mathematics in the present because this would hamper their image as teachers, but are prepared to admit that they once held those kinds of feelings in the past. Now, efforts to assess past attitudes may be criticised on the grounds that the information provided is likely to be a distortion of reality. However valid this criticism might be, it can be argued that as important as having a 'real' picture of teachers' feelings as pupils is to see their current image of themselves in the past. This is thought to be tied in some way with their image of themselves in dealing with mathematics in the present.

The items in the *Mathematics and oneself* scale aimed at assessing the extent to which teachers have felt uneasy and/or unhappy in dealing with the subject as opposed to be confident and /or pleased. The scale was split into two sub-scales, one whose items aimed at assessing present feelings (e.g. I feel a sense of insecurity when dealing with maths), and the other concerning teachers' feelings and experiences in the past as pupils (e.g. Maths was one of my best subjects when I was at school). Naturally, the items expressing confidence with and liking for mathematics were considered the favourable ones, and those reflecting their negatives were considered unfavourable.

Section 2: Attitudes towards the teaching of mathematics

Teachers' *attitudes towards the teaching of mathematics* were captured in regard to four separate but interrelated categories:

- *Aims of teaching mathematics*
- *Nature of mathematics learning*
- *The teaching milieu*
- *Role of computers in mathematics lessons.*

Aims of teaching mathematics

This attitudinal area refers to what teachers consider to be most valuable in teaching mathematics, their intended purposes and outcomes. A major source of conceptualisation of this area has its roots in national or local school syllabuses. Some authors have taken a more complex view of the issue (e.g. Ernest, 1991), and conceptualise aims of teaching mathematics in terms of different social groups (e.g. teachers, mathematicians, representatives of industry). I maintain that such identification has obvious limitations in that it weeds out different values within the same social group. I propose instead a categorisation (for any social group) that appears to be at once short and sufficiently inclusive. Three superordinate types of aims seem appropriate. These range from one based on the intrinsic value of mathematics to one completely alien to mathematics, based on the power of the curriculum. In the former case, the source of gratification for teaching mathematics is self-contained, whereas in the latter there would be a strong commitment to the efficiency of the system. An intermediate type concerns those aims corresponding to pupil-oriented educational efforts. These aims include, among others, those related to (a) applications of mathematics in life (*practical* function); (b) the development of thinking skills (*individual-disciplinary* related); and (c) the induction of pupils into further mathematics and other academic subjects (*scholarly-academic* oriented). The three classes and the five possibilities that were generated are summarised in the following figure:

<i>Intrinsic</i>	<i>Pupil-oriented</i>	<i>Extrinsic</i>
<i>Affective</i>	<i>Practical</i> (e.g.. Tool for everyday life)	<i>Curricular-Efficiency</i>
(e.g.. Its own sake)	<i>Individual-disciplinary</i> (e.g. Develop reasoning skills)	(e.g. Curriculum based)
	<i>Scholarly-academic</i> (e.g.. Basis for further maths)	

The significance of this area is that the endorsement of specific aims may be seen as a precursor to teachers' practices in the classroom. Moreover, this area is likely to be most sensitive to social and cultural factors and therefore particularly worth investigating under a cross-country vantage point. In fact, the country established goals of primary education, in general, and mathematics education, in particular are likely to be a major force in shaping teachers' views about the aims of teaching mathematics, especially in cases of countries like Portugal in which a national curriculum exists.

Note in passing that, in contrast with the other attitudinal areas, the items included under this heading were not intended to form an attitude scale. If I were to take the spirit of the Likert method of scaling into account, then I would have to have a considerable number of items for each of these five categories of aims since these deal with independent aspects of mathematics

education. This would lead to an exaggerated number of items to be included in the area and consequently to an over-estimation of its importance. Departing from the Likert method, I associated a single aim with each of those categories, bearing in mind the purpose of having the respondents to rank the five aims. However, rather than asking the respondents to give a rank order to the five aims, I considered more suitable to follow a procedure similar to the one used in the items included in the different attitude scales. That is, the respondents were asked to give an overall rating to each aim on a scale of 1-5, but the subsequent analysis was to be performed in a way different from that used for the items related to the other attitudinal areas.

Nature of mathematics learning

This attitudinal area refers to teachers' implicit theories about "what it is best for children" to learn mathematics. This area was conceptualised in terms of two distinct but related dimensions which have been stressed by several authors writing about the issue (e.g. Ausbel, Novak, and Haneslan, 1978; Skemp, 1989; Fennema, Carpenter and Peterson, 1989). The first dimension refers to the degree to which learning mathematical facts and skills takes place in isolation (*instrumental* view) versus in relation to understanding and problem solving (*relational* view) (Skemp, 1989). The second concerns the extent to which learning involves simple transfer (*transmission* view) versus construction of mathematical knowledge (*constructivist* view) (Cobb, 1988).

Many assertions and some evidence (e.g. Thompson, 1982; Lerman, 1986) support the idea that teachers' beliefs about how children learn mathematics reflect to a large extent their views of mathematics. If teachers believe that mathematics is a set of immutable truths, for example, then it makes sense that they also believe that children's mathematics learning best takes place by practising rules and procedures. The study of teachers' views of mathematics might then be amplified by examination of their opinions about the nature of learning mathematics. This area is also worth to investigate to see how substantial efforts to bring about changes in mathematics lessons in England have been "transferred" to teachers' views about how children learn mathematics.

The items in the *Nature of learning mathematics* scale were related to both the instrumental/relational dimension (e.g. Most of the time in a maths lesson should be spent with pupils practising the basic mathematical skills till they master them) and the dimension of transmission/constructivism (e.g. With little guidance most pupils should be able to discover most mathematical ideas for themselves). High scores were attributed to those items expressing either *relational* or *constructivist* learning views.

The teaching milieu

This attitudinal area refers to teachers' intentions of behaviour concerning the classroom atmosphere in connection with pupils' mathematical learning. The term *milieu* has been used by several authors (e.g. Kesler, 1985; Oberg, 1986), but its meaning has been left loose. Here, the term is taken to incorporate a series of dimensions such as (1) the teacher's role (*facilitator* versus *role model*); (2) teacher-pupil relationships (*affiliative* versus *authoritative*); (3) pupil-pupil relationships (*cooperation* versus *competition*); (4) physical setting (*pleasant* versus *tedious*); and (5) classroom resources (*rich* versus *poor*). Although distinct, these dimensions are likely to be mutually dependent. As a matter of simplification, I will label a teaching milieu which may be placed nearer the ends stated first as *flexible* whereas one located nearer the other ends will be called *rigid*.

A primary reason that makes this area a prominent one in this study is that of the relationship between the use of computers and Logo in the classroom, and the characteristics of the teaching milieu. There is some evidence to suggest that these characteristics affect the amount of initiative necessary to encourage teachers to become involved in the implementation of computers and Logo in the classroom (e.g. Ferres, 1983). Clearly, the demands on a teacher to use computers and Logo will be greater where the teaching milieu is a rigid one than a flexible one. Secondly, while there seems to be no good baseline data on how the teaching milieu is related to pupils' mathematics learning, the bridge between these two areas appears obvious. For example, if the teaching milieu is a rigid one, it is quite unlikely that pupils come to be engaged in relational and constructivist learning. In other words, a flexible teaching milieu may be regarded as the basic prerequisite to relational and constructivist learning.

The items in *The teaching milieu* scale focused on different aspects related to the classroom atmosphere as applied to mathematics lessons. They range from views expressing a *flexible* atmosphere (e.g. In my maths lessons, pupils are used to discussing their own ideas and suggestions) to a *rigid* climate that is based on teacher's authority and knowledge, and supported mainly by traditional classroom resources (e.g. Work in my maths lessons follows the textbook/workcards closely). Low scores were attributed to the items expressing the latter kind of opinions.

Role of computers in mathematics lessons

This area addresses teachers' perceptions of the practicality and usefulness of computers in the context of mathematics lessons. As computers were only recently available in Portuguese primary schools, it was felt that most teachers in Portugal would have barely-formed opinions concerning specific issues about the matter. Thus, the area was conceptualised in terms of the

general idea that computers may do many things in the service of teaching/learning mathematics and can be used in a variety of ways.

A primary reason why this area was judged of particular interest lies in the fact that the computer serves the basis for the change initiative investigated in the second sub-study. Another justification is related to the cross-countries perspective of the study. Teachers in England have been certainly exposed to more ideas about the use of computers in mathematics than the Portuguese teachers. It may be interesting to see the extent to which this difference interferes not only with teachers' attitudes towards the use of computers in mathematics, but also with their attitudes towards other aspects of mathematics teaching.

The items included in this scale focused on those issues which can give signs of teachers' acceptability of the use of computers in mathematics lessons and the ways in which they are likely to support change in mathematics education, and their opposites (e.g. Computers are specially useful in allowing children to practise mathematical skills). The items reflecting the former views were considered as favourable, and their opposite as unfavourable ones.

Section 3: Background information

The questions in this section were asked to seek for information about the first two sets of variables listed in the conceptual framework described in Chapter 3:

- *Teachers' characteristics*
- *Contextual conditions*

The information sought was intended to give a picture of the extent to which the respondents were representative of the populations surveyed, as well as to provide the opportunity to explore relationships between the respondents' attitudes and background variables. Now, empirical studies examining this kind of variables, particularly with an eye to relating these to teachers' attitudes towards mathematics and mathematics teaching are relatively rare. This lack of a solid basis to lean on left open the possibility for the inclusion of a large number of variables which I suspected could have some kind of influence on teachers' attitudes. The highly exploratory nature of this section also suggested that the questions format should be open-ended rather than closed.

Teachers' characteristics

Questions in this section covered biographical variables such as the sex and age of the respondents, as well as their academic and professional experiences. The roles of age and sex of teachers have remained relatively unexplored in teacher education studies. However, the use

of these variables is pervasive in social research. In particular, these variables are often used in official statistics to characterise teachers population.

Information sought about teachers' academic and professional experiences included: (a) the type of academic qualifications, the college or university attended, as well as the date of award; (b) highest mathematical qualifications; and (c) in-service courses in the area of mathematics taken in the past five years including title, duration and date. These were intended to illuminate the kind of knowledge and experience the respondents have had with mathematics. This has been found related to the 'impact' of a learning experience with Logo on teachers (e.g. Mitchell, 1983).

Another relevant variable that has been found to relate to several measures of teachers' attitudes and instructional practices is length of teaching experience (e.g. Berliner, 1987). Age group taught, teacher turnover, other kind of teaching experience, and other type of experience related to teaching represent another set of factors which may interact with teachers' attitudes towards mathematics and mathematics teaching and that were therefore considered as well.

Contextual conditions

Contextual conditions are frequently mentioned in case reports, and some authors have even recognised the influence of such conditions on teachers' attitudes towards mathematics and its teaching (e.g. Lerman, 1986). Nevertheless, very little seems to be known about the influence of these kinds of variables on teachers' attitudes. One possible reason for this knowledge gap is the diffuse and/or long-term impact of these variables on teachers. In fact, owing to the great mobility of the teaching profession, one may well speculate that in addition to the possible influence of current contextual conditions, virtually contextual conditions of all the schools in which teachers might have taught previously, or at least in the recent past, have some kind of effect on them. Such an enquiry would then have to take into account these possible influences, but this would yield a considerable amount of information that was certainly difficult to analyse.

Having acknowledged such complexities, I decided, nevertheless, to request prospective respondents to indicate the name of the school where they were currently members of staff. This information would in turn yield information about variables such as school type, school size and geographical situation easily available from a list of schools provided by the local educational authorities.

Moreover, teachers were asked to indicate whether they regularly used computers in their mathematics lessons and, if so, the type of software used (owing to the little availability of

educational software in Portugal, this latter question was omitted in the Portuguese version of the questionnaire). These variables were thought to constitute another potentially important (but relatively unknown) set of factors which has come on the scene recently, ones which will become increasingly relevant to examine.

Developing the attitude scales

In this sub-section, I will briefly describe the procedures undertaken to develop the attitude scales. Before that, I would like to emphasise some major issues related to the construction of Likert attitude scales.

Some issues in selecting the attitudinal items

There are at least three major issues faced by anyone developing Likert attitude scales who wants to avoid superficiality and wrongheadedness. First, one is confronted with the problem of deciding on how many items should be included in the scales. A suggestion comes from Fishbein and Ajzen (1975). In referring to the problem of attitude measurement, these authors point out that only a small number of beliefs (five to nine) about an object serve as determinants of a person's attitude towards that object. One implication of this is that there is no need to include a large number of items in a scale to assess a person's attitude towards a given object. It may be also instructive to illustrate what various mathematics education researchers have decided on the topic. The well-known Fennema and Sherman's (1976) scales to assess pupils' attitudes towards mathematics have twelve items each. In turn, the attitude scales used in the second IEA study of mathematics (Robitaille and Garden, 1989) include a number of items ranging from four to fifteen.

Another problem faced was that of selecting both *favourable* and *non-favourable* attitudinal items. It may be arguable that such designations are judgemental, and what is considered favourable for somebody may be unfavourable for somebody else. Yet, as Likert (1967) noted:

So far as the measurement of the attitude is concerned, it is quite immaterial what the extremes of the continuum are called; the important fact is that persons do differ quantitatively in their attitudes, some being more toward one extreme, some more toward the other. (p. 91)

Under such circumstances, I had to ponder what, for the purposes of this study, should be considered favourable and unfavourable. One of the criteria followed was that of considering *unfavourable* those items voicing opinions which may be said closer to a stagnant perspective of mathematics education and as *favourable* those items that in contrast are associated with the idea of change. Thus, for example, the item "Computers are especially useful in allowing children to practise mathematical skills" was assigned as an unfavourable one.

A final and perhaps most difficult problem to solve was that of ensuring the unidimensionality of the scales. Likert's method is based on the assumption that all items included in a scale refer to the same construct, so that summing up the scores attributed to each individual item the total score can be interpreted as a single measure of the person's attitude towards the construct. Likert proposed an item analysis technique which calls for calculating the correlation coefficients of each item score with the total score. Any item that correlates either negatively or too low with the total score should then be removed. As an alternative technique, it has been suggested that factor analysis (which is an extension of the correlation coefficient) should be used in order to identify the possibly different dimensions underlying a set of items (e.g. Youngman, 1979). However, neither of these techniques, could be employed at the preparatory stage of the questionnaire development since the sample used to pilot the instrument was not sufficiently large for statistical purposes. Thus, at this stage, efforts to assess the 'unidimensionality' of the scales only resulted of my best guesses corroborated by those of two mathematics education experts.

Preparatory work

Sources of the attitudinal items

The process of identifying appropriate items to included in the questionnaire started with the examination of existing instruments aimed at assessing people's attitudes towards mathematics and mathematics teaching. Some items were either borrowed or adapted from these instruments. Other items were derived from the literature in the field, and in particular from teachers' expressed opinions about mathematics and mathematics teaching in similar studies. A final source of attitudinal items consisted of assertions obtained from English primary teachers and prospective primary teachers.

Initial trial of the items

Two initial trials of the items were undertaken before the first version of the English questionnaire was compiled. First, the pools of items distributed into the seven attitudinal categories (initially, the area addressing the *role of computers in mathematics lessons* was not considered) were scrutinised by two mathematics education experts. As already stated, they judged the items in terms of their appropriateness for inclusion in the different scales. Thirty five of the statements related to the attitudes towards mathematics constructs and twenty-five items included in the attitudes towards the teaching of mathematics scales were considered to meet the criteria of validity best. These items were then ordered randomly to construct the skeleton of the two main sections of the questionnaire: *attitudes towards mathematics* and *attitudes towards mathematics teaching*. These were then presented to a small group of persons which included four mathematics education experts, five graduated students enrolled in a mathematics Master course and three primary teachers. Just as a matter of illustration and to

provide a flavour of the kind of feedback offered, here is one of the comments by one primary teacher who had tried the questionnaire with a group of colleagues in her school:

They [the teachers in her school] thought that the questionnaire was far too long and time consuming. Some of the questions needed an awful lot of thinking about if you wanted a considered opinion...

Following some modifications suggested by this this exploratory work, the initial version of the English questionnaire took finally form. Each of the two revised sections of questionnaire included twenty-two attitudinal items at this stage. In addition, each of these sections included one open question. One of the questions addressed the issue of the use of computers in mathematics teaching. The other open-ended question aimed at collecting teachers' feelings about mathematics. The two sections of the questionnaire were then assembled with a section including questions about teachers' background variables.

Translating the questionnaire

The next step was to develop the Portuguese version of the questionnaire. For that purpose, I translated the attitudinal items into Portuguese and adapted the questions included in the *Background information* section. The Portuguese version of the questionnaire was then checked by two experienced Portuguese primary teachers in order to examine the appropriateness of the questions and the wording of the attitudinal items before commencing the piloting. The attitudinal items were then backtranslated into English by two English native speakers who were fluent in Portuguese. The process was completed by having a mathematics education expert to evaluate each of two English versions of the attitudinal items (the first version and the back-translation) to assess the extent to which they were 'the same'.

Piloting the questionnaires

A mini-survey was conducted with the teachers of three primary schools of the London area and three primary schools of the Oporto area. The purpose of this small scale study was to give indications of the relative strengths and weaknesses of the questionnaire items, so that possible improvements could be made prior to the main survey. This pilot survey was administered late in July 1987 in England, and at the beginning of September 1987 in Portugal. A total of thirty-two Portuguese teachers and twenty-seven English ones answered the questionnaire.

The analysis of the teachers' answers illuminated some aspects of the questionnaire that needed to be improved. For example, one of the trends noted was that of the relatively high percentage of respondents in both countries who did not answer the open ended questions. Such finding led to discarding these questions. As a consequence of this, a set of items related to the use of computers in mathematics lessons was included.

A second development was related to the emergence of items yielding a 'high' percentage of agreement (agree or strongly agree) or disagreement (disagree and strongly disagree). According to Likert (1967) "any statement to which persons with markedly different attitudes can respond in the same way is, of course, unsatisfactory" (p. 90) and should be discarded. Associated with this contention, it was felt that an easy and straightforward convention would be well-suited to identify items which did not discriminate well among the respondents: A scale should not contain any item yielding a percentage of either agreement or disagreement higher than 80%. Similarly, items which yielded a percentage of uncertain answers higher than 80% were also rejected. In fact, it does seem reasonable to conclude that people choosing the uncertain 'category' may hold different attitudes (e.g. no opinion, lack of understanding of the item, neither agreement nor disagreement).

A major issue regarding the application of the two criteria above deserved further consideration. What should be done when an item discriminated well in one country but did not discriminate in the other country? Such item is naturally of great significance under a cross-countries perspective, and so, should not be ignored. On the other hand such item would be of little use in distinguishing respondents within one of the countries, and therefore, to include it would be wasteful. Rather than adopting a rigid solution for all the items in those conditions, the decision was made dependent upon the usability and value of each item.

Two final modifications were made regarding the items expressing aims for teaching mathematics. First, all the items should appear sequentially rather than distributed in random order. It was expected that, in this way, the respondents would take into account their relative order of preference in relation to the items. Second, it was felt that in order to prevent a massive agreement with these items, they should be stated in terms such as "The main aim to teach mathematics in primary school is ...".

THE INTERVIEWS

As stated in Chapter 3, semi-structured interviews were carried out with the teachers participating in the second sub-study, once before and once after they have attended the Logo in-service course, with the purpose of *mirroring* their attitudes towards mathematics, towards mathematics teaching and towards computers. Planning both the pre- and post-interviews involved much of the same steps undertaken to develop the attitude questionnaire, namely development of interview protocols specifying the areas to be covered and the questions to be asked, initial trials, translation of the interviews protocols, and pilot interviews. Moreover, it required that considerable efforts were undertaken in developing appropriate skills to conduct

the interviews. This section provides an overview of the areas explored by the interviews and describes several aspects concerning the preparatory work undertaken to conduct the interviews.

The interviews protocols

As already stated, the two final interview protocols which were finally developed (for the pre- and post-interviews to be conducted with the English participants) are presented in Appendix A.3 and A.4. Here, an overview is given of the areas explored by the interviews and of specific questions formulated. Both the pre- and post-interviews protocols followed the generalized outline:

- *Introduction*, aiming at establishing a good rapport between myself and the interviewees and encouraging them to answer the subsequent questions;
- *Elicitation*, focusing upon the areas under investigation; and
- *Conclusion*, providing the interviewees with the opportunity to add any information they wished.

Areas covered by the interviews

Two main areas explored during the elicitation phase were those under scrutiny in this research: (a) *Attitudes towards mathematics*; and (b) *Attitudes towards mathematics teaching*. A third attitudinal area considered particularly relevant for the second sub-study was *teachers' attitudes towards computers*. In addition to these three attitudinal areas, the following two topics were covered in the pre-interview: (1) *Background information* (matters related to the course participants' academic and professional background); and (2) *Motives for joining the course* (what prompted the participants to join the course). In turn, in the post-interview two additional areas of enquiry were related to: (1) *Course evaluation* (the participants' reactions to their involvement in the Logo course); and (2) *Pupils' outcomes* (the participants' perceptions of the value of a Logo-based learning environment in terms of pupils' outcomes).

It should be noted that while the pre- and post-interviews included the same three areas of enquiry (attitudes towards mathematics, attitudes towards mathematics teaching and attitudes towards computers), the specific questions addressing these areas were not necessarily similar on the two occasions. This reflected naturally the different rationales of the pre- and post-interviews. Whereas in the pre-interview I was willing to trace the 'history' of the participants' attitudes, in the post-interview I was interested in highlighting possible shifts in these attitudes by engaging them in medium-term retrospective thinking of how they handled their

participation in the course. The following illuminates the kind of questions addressing these three main areas both in the pre- and post-interviews.

Attitudes towards mathematics

In the pre-interview, the questions included in this section focussed upon two (or three) of the four attitudinal categories that were used in the questionnaire: how the participants felt personally in dealing with mathematics (both in the present and as pupils) and their views of (school) mathematics. Based on the results of the first sub-study, the category dealing with the usefulness of mathematics was not considered worthwhile to examine since it was reckoned that teachers tended to agree that mathematics is very important and useful. Additionally, no attempt was made to distinguish between the participants' views about mathematics as an academic discipline and as a school subject. The purpose of avoiding to make this distinction was to get a feeling of the extent to which the teachers' thinking about mathematics is driven by the subject they have to teach.

In order to elicit the participants' feelings towards mathematics, the participants were asked: "What are your attitudes towards mathematics?". The question used to evoke the participants' feelings in dealing with mathematics as pupils requested that they reported on a particularly good and a particularly bad moment in dealing with mathematics, being the choice of which moment to describe first left to the interviewees. In turn, the question focusing upon the participants' views about mathematics was worded like follows: "Now, this might be a difficult question, but I would like you to try and answer to it...If you have to explain to somebody what mathematics is about, what would you say?".

I will now proceed to outline some of the related questions devised for the post-interview. In order to get a feeling of how the participants' attitudes towards mathematics evolved during the course, the following question was planned: "In what ways has the course effected your attitudes towards mathematics?". Next, there was the important question of what they felt mathematics is about. This question was stated in similar terms to those used in the pre-interview. In effect, it had been foreseen, and the pilot and pre-interviews confirmed so, that the question is a complex one to which teachers would have given little thought. Since the pre-interviews had revealed that, in most cases, the participants' views of mathematics were hardly the result of conscious efforts to think about the issue, the possibility that they were aware of the changes which had or did not have occurred in these views would be minimal. Asking exactly the same question, then, was thought to be the best way to emphasise the need for reflection upon the issue.

A related question was used to scrutinise further the participants' views of mathematics. It aimed at examining the extent to which the participants perceived the course of mathematical nature. The question was worded in the following terms: "The course you attended was entitled *Teaching and learning maths with Logo in primary school*. Would you like to describe what kind of mathematical knowledge, if any, you might have acquired throughout the course?". If the participant gave an answer which indicate that he or she considered that the question was ludicrous, then the expression to *acquire* mathematical knowledge would be reverted to *apprehend it in a new way*.

Attitudes towards mathematics teaching

Broadly speaking, the questions included in this section of the pre-interview guide covered the same issues that those addressed by the questionnaire, namely aims of teaching mathematics, teachers' implicit views of children's mathematical learning, and description of the mathematics teaching milieu. The questions related to these two later issues were formulated in terms of the participants' intended pedagogic strategies (e.g. type of mathematical activities, classroom organisation, pupils' evaluation, and curriculum materials used). For example, one of such questions was: "How would you characterise the way you organised your maths lessons today?". Depending on the participants' response, probes would then follow to obtain either more specific or more general information. The question to elicit the participants' opinions about the aims to teaching mathematics was formulated in a straightforward way: "What are in your opinion the main purposes of teaching mathematics in primary school?".

In the post-interview, the questions about intended pedagogic strategies were replaced by questions aimed at getting a feeling of: (a) ways, if any, in which the participants used Logo with their pupils throughout the course; (b) whether or not the process of implementing Logo in the participants' classrooms would have led them to reflect upon their approaches to mathematics teaching; and (c) ways, if any, in which the participants' role as learners throughout the course would have stimulated them to think of their pupils' roles as learners of mathematics. The strategy aimed at eliciting the participants' opinions about the aims for teaching mathematics in primary school was also different from that used in the pre-interview. Five relevant opinions about the issue were selected from those expressed by the course participants in the pre-interview, and the interviewees were asked to give a rank order to these five opinions (these were to be listed in a card which was to be handed to the interviewees). It was felt that, at this point, this would be a more useful approach to help out with the analysis. In fact, several discrepancies were noted between the participants' opinions about the aims for teaching mathematics as expressed by their answers to the questionnaire and those expressed during the interview before the course started. These differences might have been associated with instrumentation effects (variations due to the use of multiple aims in the questionnaire as

opposed to an open ended question about the issue in the pre-interview). The use of comparable methods in the post-interview and the questionnaire would then help to minimise those effects.

Attitudes towards computers

There were obvious reasons for attending to and dwelling at some length on the participants' attitudes towards computers in the pre-interview. First, as earlier stated, this area was hardly addressed by the attitude questionnaire. Yet, a focus on the participants' attitudes towards computers seems essential, in that these attitudes may provide active driving forces for change in their attitudes towards mathematics and mathematics teaching, or in contrast constrain and limit change efforts. A second and overlapping reason has to do with the participants' motives for joining the course. Given the current state of the use of computers in schools in Portugal at the time in which the research was conducted, it was felt that the informational base of Logo underlying the Portuguese prospective participants would be weak to mobilise them to participate in the course. In this view, the possibilities for misunderstanding and miscalculation would be enormous, and acknowledging them was judged essential.

The questions addressing this area proceeded through several phases, beginning with a broad view about the participants' attitudes towards computers in society, and education in general, and shifting the attention to how computers could possibly be used within mathematics lessons and how effective they would be compared with other methods. In addition, there was a question about the participants' previous experience with computers.

In the post-interview, the participants were asked information about their attitudes towards computers, in general, and computers in education, in particular, much in the same way as in the pre-interview. However, given the relatively low awareness of views about the use of computers in mathematics lessons and the little acquaintance with computers shown by the course participants in Portugal, it became crucial to use a different approach to provide data on these views. The approach used then was similar to that utilised to elicit the participants' opinions about the aims of teaching mathematics. Thus, both in Portugal and in England, samples of distinct views expressed by the participants before the course were selected and listed in a card which was to be handed to the interviewees. The related question was formulated as follows:

In asking about the role of the computer in maths education during the interviews which were carried out before the course started, I got a variety of interesting answers. Here are four of them. Which of these four answers is closer to your own opinion now?

Preparatory work

Detailed planning in preparation for undertaking the interviews took two main distinct but related forms: (1) developing personal expertise to conduct the interviews; and (2) developing the interviews guides.

Developing interviewing skills

Although basic, this activity is crucial for a novice researcher who prepares for the task of conducting interviews, and is therefore an integral part of the preparatory work. The process began by studying written materials describing the practice (e.g. Powney and Watts, 1987), including manuals, descriptive articles and transcripts of interviews carried out in similar research studies (e.g. Hoyles, Noss and Sutherland, 1991). This provided a sense of the nature of the practice, and a suggestion of suitable questions, probes and prompts to use in the present study. In addition, I attended two workshops during which I had the opportunity to gain some practical interviewing experience.

I also felt that it would be useful to conduct a series of interviews with teachers and student-teachers who were taking up Logo courses. At this stage, a preliminary guide of the pre-interviews had already been devised, and the interviews served not only to gain further interviewing skills, but also to try out the logistics of carrying out the interviews. All the interviews were audiotaped, fully transcribed and subsequently examined for the purpose of assessing the strategies of interviewing and appropriateness of the language used.

Developing the interviews guides

Unlike the attitude questionnaire, the interviews were considered as flexible *mirrors* of teachers' attitudes. That is, rather than robust *mirrors*, the interviews were tools that were amenable adaptation at the interviewee's level. This was so because what was intended with the interviews was to have teachers describing their attitudes by using their own language, thus conveying a fullness of their experience. Yet it was considered equally important not to lose a certain sense of comparability of data across individuals. Thus, from the earliest stages of my preparation to conduct interviews, I developed a preliminary protocol to be used during the pre-interviews. This set out the subject areas to be covered, as well as the specific questions to be asked.

As I was developing confidence and competence in interviewing, I was also recognising the need for either altering and suppressing questions, or the order in which the different areas were explored. I also asked two senior educational researchers to review the pre-interview guide for appropriateness of the questions in terms of clarity, coherence and format. Further

modifications of the pre-interview guide were undertaken as a result of the pilot study. For example, during the pilot interviews, the questions addressing the participants' motives for joining the course were asked immediately after the questions in the *Background information* section. The tendency shown by the interviewees was that in stating the motives for their involvement with the project, they also expressed their attitudes towards computers and/or mathematics. Thus, in asking subsequently questions about these issues, I often felt constrained by the interviewees' previous replies. For that reason, I decided to place the questions addressing the participants' *motives for joining the course* at the end of the interview just before the *conclusion* section.

The process of developing the post-interview guides was shorter, but equally demanding. The decision of what areas and questions should be covered by the post-interview was only made after the experience with the participants in the pilot study. A preliminary post-interview guide was then assembled and examined critically by the same two senior educational researchers who checked the pre-interviews. The final versions of the post-interviews guides only took form after the pre-interviews with the teachers participating in the sub-study have been transcribed and preliminary analyses of the transcripts have been carried out.

A LOGO-BASED MATHEMATICS IN-SERVICE COURSE WITH AN EMPOWERMENT FUNCTION

This section outlines the Logo course developed as part of the second sub-study and describes some of the ideas which shaped the planning of the course.

The basic ideas underlying the course

As already stated, the Logo course aimed at providing primary teachers with the opportunity to learn and teach mathematics with Logo, as well as leading them to reflect upon and broaden their attitudes towards mathematics and mathematics teaching. In planning the course, I was especially concerned with this latter issue. Thus, underlying the course theoretical orientation there was first of all the image of a course with an empowering function. The frameworks brought to bear on designing the course were relatively diverse. First of all, the Microworlds course (Hoyle, Noss and Sutherland, 1991) was a most influential source of inspiration. In addition, the following theoretical ideas borrowed from the reviewed literature (that might also have been underlying the Microworlds course) were implicitly present.

Teachers are best supported in efforts to reflect upon pedagogical issues if they are immersed in a stimulating environment that sustains and increases their motivation to innovate. The very fact that the participants volunteered for the Logo course may mean that they had the motivation to innovate. Now, as Olson (1985) suggests, innovating is likely to contribute to leading teachers to reflect upon "old" attitudes and practices. I would like to suggest further that it is necessary to create incentives for sustaining and increasing teachers' efforts to innovate. Thus, in the first place, attention should be paid to generating a pleasant course atmosphere in which the participants would feel at easy and relaxed.

One possible means of tapping the participants' initial motivation to innovate is to make the new ideas relevant to their needs and expectations. Now, evidence points out that questions such as how and at what cost teachers decide to engage in innovating efforts have most likely different answers from different participants (Lomax, 1987). This suggests that one important characteristic of the course should be its flexibility and adaptability. In this view, provision of a variety of activities was to be made so that to meet their different interests, competencies and attitudes. Other factors that were thought to contribute to stimulating the participants' motivation to innovate were: instrumental support, informality, and making resources available.

Teachers should be regarded as responsible professionals whose perspectives are to be taken into account. This is an idea that has its roots in the action research paradigm (Carr and Kemmis, 1986) which informed the second sub-study. Two features were considered to contribute to enhancing the participants' sense of responsibility as teachers. First, it was considered essential that the course should include a "Logo implementation in the classroom" component. The inclusion of such component is consistent with the literature on staff development (Joyce and Showers, 1980; Guskey, 1985). Here, the participants' Logo work with their pupils was to be mainly in their hands, my role being that of cooperating with them to articulate their own plans for action, monitoring their efforts and helping them to reflect on the value and consequences of their action.

Another important feature aimed at increasing the participants' sense of responsibility as teachers was that of having them to develop a Logo microworld. This strategy appears to have been used with success in Hoyles, Noss, and Sutherland's (1991) study. However, rather than having the participants develop individual Logo microworlds as an extra-session activity (as in Hoyles, Noss and Sutherland's study), it was felt that would be more appropriate to consider the activity as a group project to be carried out during the course sessions.

Teachers are more likely to engage in reflection upon pedagogical issues if they are encouraged to interact and share ideas with their peers. Several authors have invoked the role of discussion and interaction in fostering teachers' professional growth (e.g. Pinner and Shuard, 1985; Guskey, 1985; Sparks, 1988). Thus, efforts were to be made to stimulate the participants' interaction and sharing of their learning/teaching experiences. Two features were to contribute to foster this kind of activities. First, interaction would result from having participants working in pairs with the computer. It is recognised that the visual aspect of the screen display made easily public to more than one individual provides a good opportunity to exchange information. An additional form of interaction would occur through group discussions. These have the potential to bring into the scene a variety of information and experiences which, one may speculate, take on special significance in instances that involve the use of innovative ideas and tools.

Teachers are capable of taking control of their own learning. As already suggested in Chapter 2, this is one of most complicated issues concerning how teachers learn. On the one hand, in most situations adults are regarded as able of engaging in self-directed learning. On the other hand, they may bring into a formal learning situation the image of dependent learners, and this may lead to frustration and conflict if they meet a different approach (Knowles, 1984).

Although it may be not without risks, an approach in which the participants would have more room for autonomy than they would typically exercise in a formal learning situation was considered desirable. This does not mean that there would not be explicit ideas or tasks offered to the participants, but rather that the participants should be motivated to recognise the need for self-proposed activities. Thus, the suggested activities were to include a range of alternatives from which the participants would be able to choose according to their preferences, knowledge and styles of work. These would be completed with hints for follow-up activities, the suggested ideas meant to be starting points for participants' initiated ones. Furthermore, most of the Logo ideas were to be introduced in response to the participants' learning experiences and requirements, both through information provided in the handouts and one-to-one interaction (rather than through whole group teaching).

Teachers should be encouraged to establish links between Logo and mathematics

Some evidence was offered in Chapter 2 giving support to the idea that Logo can be used as a vehicle to do mathematics. However, little is known about how the blend Logo/mathematics can be tracked and steered in any systematic sense, and the issue deserves more detailed examination. Thus, it was considered essential to encourage participants to reflect on the possible bridges between Logo and mathematics. How and the extent to which participants

would be able to build those links could then help to uncover their views of mathematics and how these views were evolving throughout the course.

Course structure

The course was designed to last for an academic term and to comprise twelve sessions, each of the sessions lasting two-and-a-half to three hours. The first five sessions were to be concentrated into a fortnight. This was intended: (a) to provide the participants with the basics of the Logo language, and the definition of procedures, as well as the technicalities of managing the computer in a relatively short period of time; and (b) to prevent them forgetting what they would have learnt and developed from one session to another. After the fifth session the participants would be introduced to the most complex features of Logo (e.g. recursion, multiple Turtles, words and lists). They were also expected to use Logo with their pupils in the classroom. From session nine onwards, the development of a Logo group extended project was the main focus of the participants' activity. The frequency of the sixth through twelfth sessions was mostly once a week with the scheduling left flexible allowing for changes to suit the convenience of the participants.

In an effort to make clear to the reader the flow of the course, an overview of the course sessions indicating the activities in which most of the participants were involved in each session is provided in Appendix C.1 and Appendix C.2. Each session would begin with an introduction of the suggested activities. Then, the participants would either work on those activities or continue working on a task they had begun in a previous session. During the sessions I would circulate among the participants, both to observe their reaction and to provide information (technical and conceptual). New concepts would be introduced mostly at an individual basis by means of handouts (see Appendix D.1 through Appendix D.4 for examples of such handouts), and only in some cases they would be introduced to the group of participants as a whole class activity. Most of the sessions would end with a group discussion aiming to bring the participants to reflect upon their activities, share their feelings, and discuss ideas about the potential use of Logo with pupils.

The position taken up in the process of the course development aspired to incorporate some of the ideas of a research model of curriculum development (Stenhouse, 1975) with some of the ideas of an action research methodology (Carr and Kemmis, 1986), namely that of the spiral of planning-acting-fact finding-reflecting steps. This brings to two important features of the course design. First, it was centred upon the development of learning activities rather than upon a specific content to be covered. Second, the session plans, that were developed for the entire range of sessions to guide the process of course implementation, were devised only after

I reflected upon the events and outcomes in the precedent session (with obvious exception of the first session plan). For that reason, although the two courses (the one held in England and that held in Portugal) were to include the same components and activities, the order in which they were presented could well be different depending upon the participants' reactions in the two countries.

In the following sub-section, three examples of learning activities are described to illustrate the thinking underlying their development. The presentation of the sessions plans is provided in a later sub-section.

Some learning activities

To give a flavour of the kind of activities that were developed as part of the course design, one on-computer and one off-computer activities are briefly described in this sub-section. (Appendix D.5 through Appendix D.12 exemplify other learning activities and the corresponding handouts used to present these activities during the course sessions). In addition, the teaching/learning activity related to the implementation of Logo in the classroom is shortly discussed in this sub-section.

Each activity is characterised in terms of its:

- *Purposes* -- what the learning activity was intended to accomplish.
- *Pedagogical approach* -- the ideas underlying the learning activity.
- *Procedures* -- the key features of the activity that represent what the participants had to do.

For the on-computer learning activities, a category of *Follow-up activities* was also included. This presents a range of possible related activities that could follow the designed activity.

An example of an on-computer activity: Playing with words (see Figure 4.1)

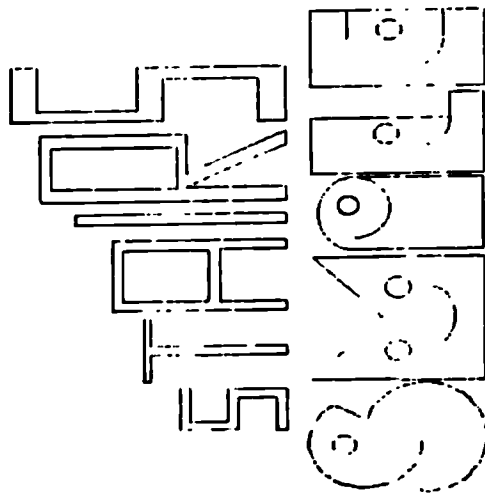
Purposes

- To provide a basis to introduce the ideas of both procedure and Turtle state.
- To provide a framework which enables to explore mathematical concepts (e.g. size and proportion, polygons and circles, symmetry).
- To stimulate the development of the idea of modularity and of breaking a problem into subproblems.
- To suggest links between mathematics and other subjects.

Playing with Words



Use the Turtle to write shapes like these



✓ Idea

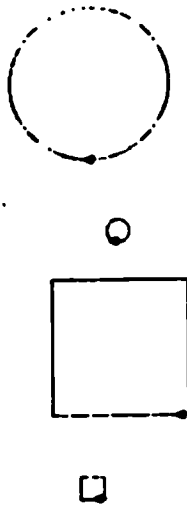
Can you make RATS from the STAIRS and MILES with a SMILE

Figure 4.1: The "Playing with Words" task

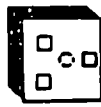
Robots...



The Turtle was taught procedures to draw the following shapes



Now, you have to draw a robot's face with them...



Choose one of the following models and write a procedure to draw it. Show it to a classmate and ask him/her to guess the robot you have chosen.

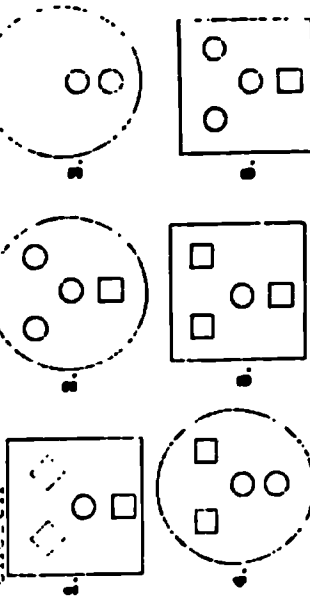


Figure 4.2: The "Robots Game" task

Pedagogical approach

Two different words to play with were suggested and the participants could then make a choice. The use of shapely words (e.g. STAIRS) presents the activity in some aesthetically pleasing form.

Procedures

The activity consisted of having participants (in pairs) to use the Turtle to draw shapely words and devise strategies to compose other words with the same letters.

Follow-up Activities

Suggestions were given to explore geometrical properties of the different letters, as well as to build patterns with letters.

An example of an off-computer activity: The robots game (See Figure 4.2)

Purposes

- To create a clear rationale for chunking a procedure into sub-procedures.
- To develop a sense of sequence and logic needed for programming in Logo.
- To develop awareness of the arbitrariness of the names of procedures.
- To contribute to change the traditional character of instructional environment as related to mathematics.

Pedagogical Approach

The main feature associated with this activity was the enjoyable aspect provided by its game nature. Moreover, being a game for teams rather than individuals, this activity emphasises interaction and sharing of ideas among the elements of the same team.

Procedures

The problem to be solved consisted of devising a super-procedure to build a robot face with four basic given shapes. The participants were arranged in small groups of three or four people, and the groups had both to solve a problem and guess the problem solved by the other group.

A teaching/learning activity: Implementing Logo in the classroom

Purposes

- To develop confidence in using Logo in the classroom.
- To explore the potential of a Logo learning environment with pupils.

Pedagogical Approach

As already stated, this activity was planned in order to increase active participation and responsible decision making in a job related situation. In addition, it was useful for research purposes. By visiting the participants' classrooms, I was able to assess how the participants used the ideas generated during the course sessions, as well as to get a further picture of the participants' views about mathematics and mathematics.

Procedures

This program component was planned only with a loose structure leaving to the participants to do whatever they wanted to do. In connection with this activity, I planned to visit the participants' classrooms twice. The first visit aimed at introducing the pupils to the Floor Turtle. In the event, each participant should have organised pupils' activities associated with its use. Afterwards, each participant was expected to continue to use the computer and Logo with their pupils as part of their daily activities. The second visit aimed at getting a sense of how the teacher and the pupils were making use of the computer and Logo to explore mathematics.

The sessions plans

Following the design of the learning activities, the thinking and shaping of the course sessions in light of the time and resources available began. For each session, a plan providing details about the session activities, their sequence, and time allocated for them was devised. Whenever appropriate, it also included the topics to be dealt with during the group discussions. The plans were to be used in a flexible way allowing for action-reflection to happen both between the sessions and within the sessions themselves. In addition, they allowed for considerable autonomy on the part of the participants to propose and engage in their own activities.

It is clearly out of the scope of this thesis to present a detailed description of all the sessions plans and of the thinking underlying their development. Here, the example of a session plan is presented to illustrate how the assumptions discussed in the previous section were embedded in the planning of the sessions.

An example of a session plan: The first session

The first session plan (for the course held in England) is included here. The choice of the first session was determined by the fact that the selection of the activities did not follow from a consideration of either activities or objectives of previous sessions. The plan, however, is not atypical. It includes the following main sections: *Timetable* and *Main topics for discussion*. The *Timetable* section contains the sequence of activities for the session. For example, in England, the timetable for the first session was as follows:

5.00-5.10	Introduction
5.10-5.20	Computers, Logo and maths
5.20-6.10	"Hands-on" Logo -- Explore, discover and draw with the Turtle
6.10-6.20	Coffee break
6.20-7.10	"Hands-on" Logo --Labyrinths and maps
7.10-7.30	Group discussion

In the first part of the session, after the participants have been required to introduce themselves, I was to make reference to the rationale and the theoretical orientation on which the course was based. Moreover, some of the pedagogical ideas underlying the use of computers in mathematics with special emphasis to those claimed by Papert (1980) were to be presented. The participants would be further invited to read at home some of chapters of *Mindstorms*.

The second part of the session was to be devoted to an initiation and use of computer and Logo. The participants would be provided with handouts illustrating graphically the basic Turtle Graphics commands and invited to explore (in pairs) the potential of these commands and using the turtle to draw. Help, if the the participants requested it, would consist first of all of trying to enact from the participants the information that they had required, and only afterwards would the information be provided if necessary. As the participants worked with the computer, decisions and possibly recast the session plan were to be made according to the flow of events.

A brief interruption (*Coffee break*) in the "hands-on" Logo activity was planned for rest and social interaction in the location of the session. It was considered that this break would constitute a good opportunity for participants to meet each other and share experiences and reactions, thus contributing to enhance interaction among participants and help develop an informal and friendly learning atmosphere.

After the break, the participants were to be given the handouts proposing the the *Maps and labyrinths* activity (see Appendix D.5 and Appendix D.6). The allocation of the participants to the different maps and labyrinths (which presented different levels of difficulty and degree of openness) was to be made in congruence with their level of ability demonstrated in the previous "hands-on" activity. At completion of one of the maps or labyrinths activity, the participants would engage with a different map or labyrinth. Moreover, they would be encouraged to propose and solve additional problems related to the maps and labyrinths provided.

The session was to end with a group discussion. This was to be, first of all, a time for the participants to pause and reflect upon their involvement with the session activities, and in particular upon the mathematics embedded in those activities. The issues for consideration in the discussion were presented in the *Main topics for discussion* section of the session plan:

1. How did you feel about this session tasks?
2. What mathematical ideas did you use?
3. How can you adapt and extend these activities for your pupils?

As already suggested this plan was not meant to be followed rigidly. It may be instructive to note, for example, that while in Portugal the session occurred much in the way it had been planned, in England some adjustments had to be made. In fact, it became clear that many of the English participants had already enough knowledge of computers and Logo to progress through the different on-computer activities more quickly than planned. Thus, these participants were offered the opportunity to engage in extra activities which had been planned for a subsequent session.

Preparatory Work

Clearly, a great deal of thought and decision-making was necessary before the Logo course was designed and implemented. Leaving aside the procedures undertaken to implement the course, I will focus here on some of the preparatory work concerning the design of the course.

It is worth considering that the starting point for designing the Logo course was the work I undertook in my Masters in Education programme during which I developed a Logo unit for primary student-teachers (Moreira, 1984). Afterwards, I gained some practical experience in running Logo-based courses both for primary student-teachers and primary teachers in Portugal (Moreira, 1986). Subsequent work took place in England where I participated as an observer in a few Logo-based in-service courses, both for primary and secondary teachers. These proved to be most useful as a form of exchanging ideas with the course tutors and gaining familiarity with English teachers. Concurrently with this kind of practical induction, I was examining both mathematical and Logo instructional materials.

On the basis of these experiences, a number of learning activities which were felt would be appropriate to include in the Logo course were chosen. In the same way that the initial versions of the attitude questionnaire and interview guides were examined critically by scholars, the relevance of those learning activities were scrutinised by two mathematics education experts.

As a final step to plan more effectively for the Logo course, I carried out a pilot course which aimed at testing the appropriateness of the materials developed, the pace of the sessions, as well as the methods of data collection. This will be shortly described in the following sub-section.

The pilot course

The pilot course was run in the Spring term of 1988. It involved a group of primary teachers of an outer London borough who had applied to attend to a Logo INSET course in the borough teachers' centre. The course consisted of six after school sessions of two hours on a weekly basis, and was run by myself in collaboration with the two people responsible by the teachers' centre computing unit. Although twenty-one primary teachers attended the course, only seven of them were considered for the purpose of the pilot study. These seven participants were interviewed, both before and after the course, and were observed more intensively throughout the course sessions.

Viewed overall, the pilot study made a significant contribution to my thinking about and subsequent development of the course. In particular, the following issues were identified. First of all, it suggested that the planned materials and on-computer activities were, in general, appropriate and able to generate enthusiasm and involvement among the participants. Also, the participants' reactions to the Floor Turtle activities were quite favourable, thus appearing to indicate that more emphasis should be put on this kind of work. In contrast, some of the off-computer activities of the type of "the Little People model" (Harvey, 1985) to illustrate Logo programming features appeared to lead to little participants' involvement. Obviously, more attention would have to be placed on the implementation of these activities. As far as the "implementation of Logo in the classroom" component is concerned, it became rather clear that it was a demanding task. Some participants showed little willingness in engaging in such activity. This fact suggested the need for acceptance on the main study being conditional to the prospective participants' commitment to implement Logo in their classrooms.

The pilot study also drew attention to the following issues concerning the methods of data collection throughout the course sessions. Collecting data about the participants' interactions with the Logo course was problematic. As already stated in Chapter 3, note-taking during the course sessions was found to demand considerable time and skills, and was almost entirely replaced by a kind of diary written after the sessions. It was, therefore, absolutely necessary to secure the utilisation of other kinds of data to provide a better basis for interpretation and understanding of the participants' interactions, namely the use of dribble files. This had already been planned, but the characteristics of the computers utilised in the pilot course imposed serious restrictions to their use. Moreover, complexities related to conducting and retrieving group discussions were also noted. For that reason, it was decided that the use of group discussions for research purposes should be kept to a minimum, serving mainly as a catalyst for the participants' interaction and reflection upon the ideas generated during the course.

SUMMARY

This chapter has contained an overview of the main instruments which were developed as part of the research, both to mirror teachers' attitudes towards mathematics and mathematics teaching, and to effect change on these attitudes. The chapter was in three main sections, each dealing with one type of the tools developed: the attitude questionnaire, the interviews, and the Logo-based mathematics in-service course. My intention has been to provide a sense of the thinking and practices involved in the development of these instruments. In particular, the chapter has emphasised that considerable efforts were made to develop the "best of possible" research tools.

The chapter is to provide a valuable context for the next two chapters, which examine the findings of the two sub-studies making up the research. In fact, as has been stressed the instruments developed should be seen as *mirrors* which give no more than *distorted* pictures of what teachers attitudes are and of how they might be changed. That is, in a sense these tools set limits as to the findings of the sub-studies, and therefore these should be seen with reference to these instruments.

CHAPTER 5

A snapshot of primary teachers' attitudes towards mathematics and mathematics teaching

(Findings of the attitude survey sub-study)

This chapter presents the findings of the two sweeps of the survey of primary teachers' attitudes towards mathematics and mathematics teaching, which were conducted inside the boundaries of Suffolk County Council in England, and of Viseu district in Portugal. As stated in Chapter 3, the purpose of this survey was to provide pictures of the attitudes of primary teachers in both countries which would mainly serve as a baseline from which to act in the second sub-study.

Throughout the chapter, and as a matter of simplification, I often distinguish the respondents in the two countries by referring to them as the English primary teachers and the Portuguese ones. Of course, there is no claim that the populations surveyed are representative of the populations of the two countries. The results of the survey, therefore, provide no more than a provisional *snapshot* of what the attitudes of English and the Portuguese primary teachers might be.

The chapter is organised in two main sections which present the results of the survey. In the first section, the respondents' attitudes towards mathematics and mathematics teaching as assessed by the attitude questionnaire are examined. The second section explores relationships between the respondents' attitudes and selected background variables. Complementing these two sections, descriptive information about the characteristics of the primary teachers who participated in the survey in England and Portugal is presented in Appendix E.1. Such a complementary information provides a sense of the extent to which the teachers' participating in the survey are representative of the populations surveyed. In addition, it allows for comparison between the characteristics of teachers in both countries. (With regard to this latter aspect, it should be noted in passing that with the exception of the variable *age*, there are considerable differences in the characteristics of the teachers in the two countries).

Before presenting the results, and as an introduction to them, some methodological issues which only emerged during the undertaking of the research are considered.

Introduction to the results

In considering the results of the survey, an important distinction must be noted between the response rates in the two countries. As stated in Chapter 3, the numbers of questionnaires returned within the time due corresponded respectively to about 20% of the primary teachers in Suffolk and 84% of the primary teachers in Viseu. Three reasons may have contributed to this substantial difference. The first has to do with the different level of teachers' tolerance to participation in studies of this kind. Non-response in England may be associated with a higher level of "tiredness" on the part of teachers due to participation in similar studies in this country. Another reason may reflect the different level of teachers' compliance to authority in the two countries. In both countries, the surveys had the sponsorship of the local education authorities, but it is possible that the Portuguese teachers were more likely to feel that answering the questionnaire was obligatory than their counterparts in England. This is in line with the results of a previous study involving England and Portugal (e.g. Hofstede, 1980) suggesting higher conformity among the Portuguese employees than among the English ones. It is possible that the same kind of relationship holds with regard to teachers as well.

The third reason has to do with the procedures involved in the administration of the questionnaire. Efforts were made in order to have similar strategies in both countries. The questionnaires were sent to the headteachers who would distribute them among the teachers in their schools. Given the difference in the nature of the role of headteachers in both countries, however, the result of such strategy seemed not to have been fully successful. In England, many headteachers might have decided not to distribute the questionnaires in their schools, as the following suggests. Shortly after the questionnaires have been returned, I contacted some schools at random to examine the reasons for teachers not having answered the questionnaire. In two of the schools contacted the questionnaire had not been distributed to the teachers by the headteacher. One of the headteachers explained that he did not distribute the questionnaire as it was his understanding that teachers were too busy to be asked to fill in the questionnaire.

Another serious (given the high percentage of cases involved) problem in interpreting the results of the survey occurred with the Portuguese respondents. It was soon realised that many of the Portuguese teachers' answers to the attitudinal items did not convey the attitudes of the individual respondents, but represented rather the opinions of two or more teachers within the same school. Indeed, it would not be possible to assume that teachers from the same school had given the same or similar answers to the attitudinal items if they had not answered the

questionnaire as a conjoint activity. No doubt, this type of behaviour is in itself a significant finding from a cross-country perspective. For the purpose of statistical analyses, however, the inclusion of such a high number of questionnaires in these conditions would yield a considerable degree of distortion. For this reason, most of the questionnaires which appeared not to reflect personal attitudes were eliminated. But given that the attitudes of the 'cheating' respondents were also important to take into account, for each set of 'contaminated' questionnaires one was selected at random to be included in the subsequent statistical analyses. The number of questionnaires fully analysed in Portugal was then reduced to 1156, corresponding to about 71% of the teachers in the Viseu district.

These problems notwithstanding, it is important to mention that the characteristics of the respondents (in both countries) whose questionnaires were fully analysed were in general very close to the two populations' characteristics, at least in term of the available official statistics (see Appendix E.1 for more details about this issue).

THE RESPONDENTS' ATTITUDES TOWARDS MATHEMATICS AND MATHEMATICS TEACHING

As suggested in Chapter 3, the analysis of respondents' attitudes (with the exception of the issue of the respondents' opinions about the aims of teaching mathematics) was carried out by means of two methods: individual items analysis and scales summary scores analysis. The following two sub-sections present the results associated with these analyses.

Individual items analysis

This sub-section concerns the analysis of the individual items making up the nine attitudinal areas considered (recall that from the eight areas initially considered, the *Mathematics and oneself* scale was split into two sub-scales). For each attitudinal area, the analysis of the English respondents' answers will precede the analysis of those concerning the Portuguese ones, and then differences and similarities between the two groups of respondents will be discussed. (Throughout the sub-section, the term *endorsement* is often used to refer to either agreement or strong agreement with an item, whereas the word *rejection* is used for cases in which the respondent either disagreed or strongly disagreed with an item.)

Nature of mathematics

The four items included under this heading, as well as the frequencies and percentages of answers to these items are shown in the Table 5.1.

Table 5.1: Frequencies and percentages* of the responses (on a scale of 1-5) to the items included in the *Nature of mathematics* attitudinal area (in England and in Portugal)

	England					Portugal						
	Strongly disagree 1	Strongly disagree 2	3	Strongly agree 4	Strongly agree 5	Missing	Strongly disagree 1	Strongly disagree 2	3	Strongly agree 4	Strongly agree 5	Missing
5. You can only understand mathematics if you have a logical mind	77 13.3	225 38.9	93 16.1	61 27.9	22 3.8	2	168 14.6	451 39.2	16 13.9	312 27.1	60 5.2	9
8. Mathematics is consistent, certain and free of ambiguities	52 9.9	214 37.2	92 16.0	182 31.6	31 5.4	4	10 0.9	95 8.3	122 10.6	465 40.6	454 39.6	14
12. Mathematics is the science of formal structures and rigorous logic	37 6.5	178 31.3	155 27.2	21 31.3	11 3.7	0	16 1.4	78 6.9	153 13.6	546 48.5	332 29.5	35
13. Only people with a very special ability can learn maths	244 42.1	271 46.8	34 5.9	21 3.6	9 1.6	1	343 29.8	612 53.2	103 9.0	75 6.5	17 1.5	10

* Numbers in *italics* represent percentages, whereas numbers in plain text format represent frequencies

England

Perhaps the most striking aspect that emerges from the English teachers' answers to the items included in this scale is the almost perfect balance between teachers who endorsed Item 8 and Item 12, and those who rejected them. Naturally, it does not necessarily follow that the respondents are divided into two groups. In fact, Spearman correlation coefficient between the two items is relatively low (although significantly different from zero). These results are of interest in that they suggest that the traditional perspectives of mathematics as an immutable field and formal subject have been shaken. The same kind of interpretation may be triggered by the high percentage of respondents who opted for the "uncertain" category in answering these two items. With regard to this aspect, it is worth mentioning that the percentage of uncertain responses to the item expressing a *formalist* view of mathematics (Item 12) was over 27%.

Irrespective of their epistemological views of mathematics, the great majority of English teachers tended to reject an *elitist* perspective of the subject. This general trend is rather strong in the case of the opinion expressed by Item 13 with which about 90% of the teachers disagreed or strongly disagreed.

Portugal

The answers of the Portuguese teachers to the items addressing this area reflect two different tendencies. First, the Portuguese respondents overwhelmingly (almost 80%) endorsed Item 8 and Item 12. This indicates that the Portuguese teachers have a tendency to hold an *absolutist* (Lerman, 1986) perspective of mathematics. Second, it is clear that the Portuguese teachers reject the idea that mathematics is an *elitist* subject. Indeed, more than 81% of the respondents disagreed or strongly disagreed with Item 13 which affirms that only people with very special ability can learn mathematics. In turn, on Item 5, which expresses a weaker version of this idea, there is a gradation of opinions, but still more than half of the respondents rejected this view.

Cross-country comparison

There were considerable differences between the two countries as to the view of mathematics as a formal and fixed body of knowledge. The results suggest that the Portuguese teachers tend to have a more *absolutist* view of the nature of mathematics than their counterparts in England. For example, only about 37% of the English teachers endorsed Item 8, which states that mathematics is consistent, certain and free of ambiguities, whereas in Portugal over 80% of the respondents agreed or strongly agreed with it. Such a fact may reflect the "state of the art" of school mathematics in England. Indeed, what may be called the "English primary curriculum" has been relatively broad and investigative compared with the traditional and formal approach

dominant in Portugal. What I am pointing to is that new ideas about school mathematics may be a pathway into the teachers' views of the nature of mathematics. For many English teachers, however, the new developments in mathematics education may have left them in a state of uncertainty and perhaps confusion in respect of their views about the nature of mathematics.

In contrast with the previous items, the differences between the English and Portuguese teachers on the items addressing the *elitist* feature of mathematics tended to be rather small. In both countries, the respondents rejected the view that mathematics is only for a chosen few. This pattern of answers did not confirm the commonly-held prejudice that mathematics is a difficult and special subject. An explanation for this may lie in a tendency for the respondents to express their opinions about mathematics of the primary school curriculum rather than about mathematics itself.

Mathematics as a subject

The items included in this scale as well as the frequencies and percentages of teachers' responses are presented in Table 5.2.

England

The distribution of the English teachers' answers to the five items included in this scale is highly asymmetrical. The results suggest that the vast majority of the respondents hold the view that there is a place for creativity and changeability in the mathematics taught in school. It is especially relevant that almost 90% of the respondents rejected the view that in mathematics there is generally one best way to solve a problem (Item 13a¹).

Portugal

The picture of the Portuguese respondents' views about school mathematics is not so clear. On the one hand, their responses to Item 2 and Item 3 seem to reflect that most of them perceive school mathematics as a creative and changeable subject. This contrasts with the image obtained when one looks at their answers to Item 13a) and Item 18. Indeed, there is an almost perfect balance between those teachers who see school mathematics as mainly a set of rules to solve problems (Item 18) and those teachers who disagree with this proposition. Most striking, however, is the fact that over 80% of the Portuguese respondents appeared to believe that there is generally one best way to solve a mathematical problem (Item 13a).

Cross-country comparison

The most striking point emerging from the comparison of these results across the two countries relates to the respondents' answers to Item 13a), expressing that a mathematical problem

¹ This item was previously included in the *Attitudes to the teaching of mathematics* section as Item 13.

Table 5.2: Frequencies and percentages* of the responses (on a scale of 1-5) to the items included in the *Mathematics as a subject attitudinal area* (in England and in Portugal)

	Table 5.2: Frequencies and percentages* of the responses (on a scale of 1-5) by area (in England and in Portugal)										
	England					Portugal					Missing
	Strongly disagree 1	Strongly disagree 2	3	Strongly agree 4	Strongly agree 5	Strongly disagree 1	Strongly disagree 2	3	Strongly agree 4	Strongly agree 5	
2. School mathematics will change dramatically in the near future	10 1.7	140 24.5	128 22.4	237 41.1	57 10.0	38 3.3	159 13.8	312 27.2	490 42.6	150 13.1	19
3. Mathematics is as a creative subject as art and music	21 3.5	130 22.6	77 13.4	251 43.6	97 16.8	60 5.3	167 14.6	151 13.2	554 48.6	209 18.3	19
7. Almost anybody can learn maths if it is properly taught	12 2.1	78 13.5	70 12.1	278 48.2	13 24.1	18 1.6	92 8.0	105 9.1	593 51.3	347 30.0	5
13a. Each mathematical problem generally has only one best way to get the solution	255 44.1	265 45.8	30 5.2	25 4.3	3 0.5	16 1.4	105 9.2	93 8.1	691 60.2	242 21.1	13
18. Mathematics is mainly a collection of rules for solving problems	148 25.7	230 39.9	71 12.3	118 20.5	9 1.6	130 11.3	418 36.4	127 11.1	351 30.6	122 10.6	12

* Numbers in *italics* represent percentages, whereas numbers in plain text format represent frequencies

generally has one best way of being solved. As a matter of fact, this item yielded the most startling difference between the respondents' attitudes in the two countries: whereas in Portugal more than 80% of the respondents endorsed this view, in England about 90% of the teachers rejected it. Such a result gives strong support to the idea that the Portuguese teachers are more likely to have a rule-oriented perspective of school mathematics than their counterparts in England.

For the Portuguese teachers then, the shifts that have taken place at the primary mathematics curriculum level may have led them to develop the view of the changeability of the subject (Item 2). But either the changes in the curriculum have not pointed to a less rule-oriented perspective of the subject or they have not been accompanied by efforts to bring teachers to reflect upon the curricular changes and its implications in the methods of teaching the subject. Thus a prescriptive view of mathematics may have remained largely unaltered.

Value of mathematics

The frequencies and percentages of answers to the items included under this heading are displayed in Table 5.3.

England

As the figures in Table 5.3 show, the great majority (over 85%) of the English teachers indicated that mathematics is a very important subject to study (Item 6). This importance seems to derive from the fact that a knowledge of mathematics is needed both to study other school subjects (Item 16) and in everyday life (Item 17).

The responses to the other item included under this heading, however, produced an almost reversal of this pattern. Indeed, about 47% of the respondents agreed or strongly agreed with the item affirming that there is little need for mathematical knowledge beyond very elementary mathematics (Item 19), ten percentage points higher than that of the respondents rejecting this opinion. Quite a high percentage of uncertain answers (about 15%) to this item, however, may mean that this reversal of opinion about the importance of mathematics has to do, at least partly, with a poor wording of the item.

Portugal

The Portuguese teachers affirmed to an extraordinary degree (about 89%) the opinion that "Maths is one of the most important subjects to study" (Item 6). This disposition to see mathematics as an important subject is corroborated by their answers to Item 16 and Item 17. In fact, similar percentages of respondents endorsed the importance of mathematics in terms of its usefulness in everyday life and in studying other subjects. On the other hand, their answers

Table 5.3: Frequencies and percentages* of the responses (on a scale of 1-5) to the items included in the Value of mathematics attitudinal area (in England and in Portugal)

	England					Portugal						
	Strongly disagree 1	Strongly disagree 2	3	Strongly agree 4	Strongly agree 5	Missing	Strongly disagree 1	Strongly disagree 2	3	Strongly agree 4	Strongly agree 5	Missing
6. Maths is one of the most important subjects to study	9 1.6	34 5.9	43 7.4	293 50.5	20 34.7	1	14 1.2	63 5.4	54 4.7	564 48.7	462 39.9	3
16. Maths is very useful because it helps in the study of other subjects	4 0.7	31 5.3	52 9.0	339 58.4	154 26.6	0	8 0.7	48 4.2	64 5.6	664 57.6	368 31.9	8
17. You can get along perfectly well in everyday life without mathematics	256 44.0	246 42.4	31 5.3	31 5.3	17 2.9	0	537 46.9	476 41.5	32 2.8	76 6.6	25 2.2	14
19. There is little need for more than very elementary mathematics in most jobs	51 8.8	171 29.5	85 14.7	240 41.5	32 5.5	1	94 8.2	363 31.6	182 15.9	450 39.2	59 5.1	12

* numbers in *italics* represent percentages, whereas numbers in plain text format represent frequencies

to Item 19, which expresses the value of mathematics in terms of its utilisation in most jobs, yielded a certain balance between those teachers who agreed with the statement and those who disagreed. There is even a slight tendency for not considering the utility of mathematics with regard to this aspect, but the great percentage of uncertain answers to this item leaves some doubts about this tendency.

Cross-country comparison

The overall pattern of responses of teachers in both countries to the items addressing this area was remarkably similar. It is interesting to note that this scale was the only one in which there were no statistically significant differences between the two countries in the answers to its items. Mathematics is judged of vital importance both in England and in Portugal, the percentage of answers reflecting this importance being more than 80% in three of the four items initially included in the scale. The relevance of mathematics is seen more in terms of its usefulness in everyday life and as a support for the study of other subjects rather than say its practical value in jobs.

At first glance, this similarity of results across the two countries seems surprising given the emphasis that has been put on 'practical maths' in primary schools, as well as the strong endorsement of the study of mathematics in terms of its value in today's world by governmental sources in England. The similarity of results across countries may be seen in the light of strong traditions about mathematics giving it the status of one of the most important subjects of the school curriculum. Given the great uniformity of the respondents' opinions about the importance of mathematics in both countries, there is little room for entertaining further consideration of this issue.

Mathematics and oneself (in the present)

The results for the the items included under this heading are shown in the Table 5.4.

England

Overall the results suggest that the English teachers tend to enjoy and feel confident in dealing with mathematics, although there were large differences in the degree to which they endorsed or rejected the opinions stated in the items included under this heading. The varying degree of endorsement or rejection is especially notable in the statements associated with enjoyment of the subject. Over 80% of the respondents endorsed Item 14 (which expresses a general feeling of enjoyment of mathematics) and Item 15 (stating that "There is a fascination in studying maths irrespective of its usefulness"). When the assertion is more personal and specific, the percentage of respondents stating enjoyment decreases considerably. For example, only about 38% of the respondents endorsed Item 11 stating that "I like all aspects of mathematics", and

Table 5.4: Frequencies and percentages* of the responses (on a scale of 1-5) to the items included in the *Mathematics and oneself* (in the present) attitudinal area (in England and in Portugal)

	England					Portugal						
	Strongly disagree 1	Strongly disagree 2	Strongly disagree 3	Strongly agree 4	Strongly agree 5	Missing	Strongly disagree 1	Strongly disagree 2	Strongly disagree 3	Strongly agree 4	Strongly agree 5	Missing
9. I enjoy talk to other people about maths	58 10.0	141 24.4	86 14.9	224 38.7	70 12.1	1	57 4.9	217 18.8	132 11.4	583 50.4	167 14.4	4
10. I find maths confusing	149 25.9	244 42.4	69 12.0	88 15.3	26 4.5	4	310 26.9	493 42.8	108 9.4	210 18.2	30 2.6	9
11. I like all aspects of mathematics	56 9.7	229 39.5	73 12.6	148 25.5	74 12.8	0	56 4.8	365 31.6	208 18.0	386 33.4	141 12.2	4
14. Mathematics is fun and exciting	10 1.7	43 7.5	47 8.2	293 51.0	182 31.7	5	12 1.0	86 7.5	78 6.8	655 56.9	321 27.9	8
15. There is a fascination in studying maths irrespective of its usefulness	14 2.4	52 9.0	36 6.2	295 50.9	182 31.4	1	36 3.1	217 19.0	187 16.3	537 46.9	168 14.7	15
20. I feel a sense of insecurity when dealing with mathematics	149 25.8	220 38.1	54 9.3	121 20.9	34 5.9	2	296 25.7	584 50.8	94 8.2	153 13.3	23 2.0	10

* numbers in *italics* represent percentages, whereas numbers in plain text format represent frequencies

little more than 50% agreed or strongly agreed with Item 9 stating that "I enjoy talking to other people about maths". In turn, the percentage of respondents who reported that they feel at ease in dealing with mathematics (Item 10 and Item 20) varied between 64% and 68%.

Portugal

Overall, there were more respondents stating that they liked and felt confident in dealing with mathematics than those expressing opposite feelings. The *liking* and *confidence* dimensions, however, show some differences. Indeed, the percentage of teachers who endorsed the items associated with the enjoyment dimension varied from 45% (Item 11) to 85% (Item 14). In turn, between about 70% (Item 10) and 75% (Item 20) of the respondents stated that they felt confident with mathematics. If there was a tendency to give socially acceptable answers, then for the majority of the Portuguese respondents it is more important to convey the idea that they are confident with mathematics than to say that they enjoy the subject that they have to teach. This may indicate a tendency to appear boastful about their ability to teach the subject.

Cross-country comparison

Differences between countries on the items included under this heading were comparatively small. Overall the respondents in both countries tended to indicate that they enjoy and feel competent in dealing with mathematics. It is possible that the results may give a degree of false positive response as a result of a tendency to give socially acceptable answers. In England, a further reason can be found to explain the relatively high level of 'favourable' feelings about maths. Given the low level of response rate among the English teachers, one may wonder whether the teachers who answered the questionnaire were among those who hold most 'favourable' feelings about the subject.

There was, however, a substantial difference in the extent to which the two groups of teachers endorsed Item 15 which states that "There is a fascination in studying maths irrespective of its usefulness". Indeed, the English teachers were more likely to endorse this item than the Portuguese (by a difference that amounts to almost 20 percentage points). One possible interpretation for this difference would be that the English teachers have been more exposed to the idea that mathematics is a creative subject and to the "beauty of mathematics" than their counterparts in Portugal.

Nevertheless, in both countries, there remains a substantial minority of respondents who showed relatively little enthusiasm for mathematics and/or perceived themselves as lacking confidence with the subject. Another common feature relates to the relatively high correlation coefficients among the items making up this scale. That is, teachers who enjoy mathematics tended also to feel confident with it.

Mathematics and oneself (as a pupil)

Table 5.5 shows the frequencies and percentages of answers to the items included in this scale.

England

There were substantial differences in the ways the English teachers responded to the three items addressing this area. First, and most significant, is that the item stating that mathematics was one of the respondents' best subjects when they were at school elicited an almost *symmetrical* pattern of answers (with a slight tendency for the 'disagreement' side of the scale). By comparing this result with the figures presented in the previous sub-section, it seems legitimate to infer that there were considerable 'positive changes' in the extent to which the respondents perceive themselves as good at mathematics since they were at school. One possible explanation for that is, as suggested in Chapter 4, that there might be many teachers who do not mind admitting that they were not good at mathematics as pupils, but feel reluctant to admit so in the present. Second, it is also worth noting the large percentage (about 67%) of respondents who rejected Item 4 ("I hated mathematics when I was at school"). Finally, a substantial but smaller majority (about 59%) of the respondents rejected Item 21 stating that the mathematics they were taught at school was relatively irrelevant.

Portugal

In general, the Portuguese teachers reported highly 'favourable' sentiments towards mathematics as pupils. Over 60% of the respondents agreed or strongly agreed with the statement affirming that mathematics was their best subject at school (Item 1), while about 77% rejected Item 4 stating that they hated the subject. Perhaps the most significant feature of the answers of the Portuguese teachers to the items included under this heading was the large percentage of respondents (over 80%) who rejected the Item 21, which states that "Most of the mathematics I studied at school was a waste of time". It seems that the Portuguese respondents tended to attach a great deal of importance to the study of traditional mathematics in school .

Cross-country comparison

In contrast with what happened with the items concerning the respondents' personal feelings about mathematics in the present, the Portuguese and the English respondents reacted differently to the items assessing their feelings about the subject as pupils. Overall, the Portuguese teachers tended to give a good image of themselves as pupils far more frequently than the English teachers did. For example, the percentage of the respondents in Portugal who endorsed Item 1 expressing the idea that mathematics was one of their best subjects at school was 20 points higher than that of their counterparts in England.

Table 5.5: Frequencies and percentages* of the responses (on a scale of 1-5) to the items included in the Mathematics and oneself (as a pupil) attitudinal area (in England and in Portugal)

	England					Portugal						
	Strongly disagree 1	Strongly disagree 2	3	Strongly agree 4	Strongly agree 5	Missing	Strongly disagree 1	Strongly disagree 2	3	Strongly agree 4	Strongly agree 5	Missing
1. Maths was one of my best subjects when I was at school	126 21.8	163 28.2	46 8.3	129 22.3	114 19.7	2	65 5.7	243 21.2	134 11.7	415 36.2	292 25.3	13
4. I hated mathematics when I was at school	233 40.3	154 26.6	41 7.1	85 14.7	65 11.2	2	574 50.1	307 26.8	100 8.7	114 9.9	51 4.5	14
21. Most of the mathematics I studied at school was a waste of time	108 18.7	232 40.1	48 8.3	131 22.6	60 10.4	1	478 41.5	484 42.0	49 4.2	109 9.2	36 3.1	7

* Numbers in *italics* represent percentages, whereas numbers in plain text format represent frequencies

Another striking difference, and one perhaps significant in educational terms, is that related to the relevance of the mathematics the respondents did at school. The Portuguese respondents reported the greatest amount of relevance by almost 25 percentage points. It may be the case that the least relevance attributed by the English respondents to the mathematics they studied in school is associated to the considerable changes in school mathematics in England over the last 30 years.

Aims of teaching mathematics

The results concerning the responses to the items addressing the respondents' opinions about the aims of teaching mathematics are shown in Table 5.6.

England

The figures presented in the table clearly show that the English respondents were able to discriminate about the various importance of the five aims of teaching mathematics. The *practical* aim (Item 2) was the most favoured one, with about 90% of the respondents endorsing it. It is worth noting that over 39% of the respondents strongly agreed with this item (a rather high extreme value). Beyond these kinds of practical considerations, the English respondents also associated the importance of the teaching/learning mathematics with its potential to foster pupils' overall intellectual development (Item 2), another traditional and commonly held belief. Over 81% of the respondents endorsed this item.

Still considered an important aim, with over 58% of the teachers agreeing or strongly agreeing with it, was that related to the appreciation of mathematics (Item 1). Given that this aim does not form part of the traditional goals of teaching mathematics, this represents an important result. Next in importance comes the *scholarly-academic* aim (Item 4), with about half of the respondents agreeing or strongly agreeing with it. Not unexpectedly, the *curriculum efficiency* aim (Item 5) was seen as the least important aim endorsed by only 12% of the respondents.

Portugal

As Table 5.6 shows, the Portuguese respondents gave preference to the three *pupil-oriented* aims. The corresponding percentages were over 91% for the *practical* aim (Item 2), about 86% for the *scholarly-academic* aim (Item 4) and 80% for the *individual-disciplinary* aim (Item 3). Perhaps the most significant point is the high percentage of endorsement of the scholarly academic aim encompassing the notion of enticing pupils into the study of further mathematics. The strong commitment to this aim may reflect a serious concern of Portuguese primary teachers, and it is most likely related to the existence in Portugal of a national curriculum. This implies that at the end of each grade level children should attain certain standards in order to be

Table 5.6: Frequencies and percentages* of the responses (on a scale of 1-5) to the items included in the Aims of teaching mathematics attitudinal area (in England and in Portugal)

	England					Portugal						
	Strongly disagree 1	2	3	Strongly agree 4	Missing 5	Strongly disagree 1	2	3	Strongly agree 4	Missing 5		
1. The main aim to teach maths is to enable pupils to appreciate and enjoy it for its own sake	14 2.4	134 26.9	67 11.7	215 37.6	122 21.3	8	56 5.0	235 20.9	152 13.5	493 43.7	191 16.9	33
2. The primary purpose of teaching maths is to provide a tool which can be used to meet the needs of everyday life	7 1.2	58 10.1	42 7.3	289 50.3	179 39.1	5	9 1.8	59 5.1	30 2.6	628 54.2	432 37.3	2
3. The main objective of the study of maths is to develop reasoning skills that are necessary to solve problems	4 0.7	57 9.9	46 8.0	335 58.4	132 23.0	6	20 1.7	146 12.7	64 5.6	598 51.9	324 28.1	8
4. The main reason for teaching maths is to develop a foundation upon which subsequent maths can be learned	37 6.5	174 30.4	78 13.6	221 38.6	63 11.0	7	6 0.5	48 4.2	109 9.5	659 57.3	329 28.6	9
5. The main goal of teaching maths is to produce students who can perform the maths tasks specified in the curriculum	198 34.6	262 45.7	44 7.7	54 9.4	15 2.6	7	125 11.9	536 50.9	112 10.6	309 29.3	72 6.8	6

* Numbers in *italics* represent percentages, whereas numbers in plain text format represent frequencies

able to pursue the following level. Although this is valid for all curriculum areas, this hierarchy of knowledge is probably more evident in mathematics than in others.

Far behind of these three aims, thus reflecting the relative lack of emphasis placed by the Portuguese respondents on it, came the aim related to the appreciation of mathematics (Item 1). Nevertheless, this aim was still endorsed by more than half of the respondents. The *curriculum efficiency* aim (Item 5) was the least favoured one, but there was still considerable percentage of teachers who agreed or strongly agreed with it (about 36%).

Cross-country comparison

First of all, it may be interesting to examine the extent to which the respondents in both countries were able to discriminate the importance of the several aims. Analysis of the inter-items correlation coefficients shows that the Portuguese respondents were more likely to give the same importance to two or more aims than the English ones. This being so, one has to be especially cautious in making comparisons across countries on the basis of percentage differences and similarities. Alternatively, comparisons can be made by using the relative rank order of the items in the two countries.

A major feature which emerges from this kind of comparison is that the Portuguese and English respondents tended to consider the same aims as the one of major importance and the one of minor importance. In both countries the teachers stressed above all the use of mathematics in everyday life situations (Item 2). Also both samples accorded minor importance to the aim related to the curriculum (Item 5). Exceptionally, it may be useful at this point to compare the percentages of the Portuguese and English teachers endorsing this latter aim. Not surprisingly, given the existence of a national curriculum in Portugal, a considerably higher percentage (almost 25 points) of respondents in this country agreeing or strongly agreeing with this aim.

Another interesting point in comparing the results between the two countries is that concerning the almost reversal of the rank order of the *scholarly-academic* aim (Item 4) and the *affective* aim (Item 1). Indeed, the *scholarly-academic* aim seems to be of considerable importance for the vast majority of Portuguese teachers (being ranked in second place) and of relatively little importance in England (fourth in rank order). Such a difference may be attributed to a view of mathematics as an hierarchical subject emphasised in Portugal by the imposition of national guidelines. As far as the affective aim is concerned, in Portugal this was considered the fourth important one whereas in England it was the third one in rank order far ahead of the *scholarly-academic* aim. The relevance of the affective aim in this latter country may be associated with

the efforts to introduce new approaches to primary mathematics in this country which focus on the use of practical activities and games.

Nature of learning mathematics

In Table 5.7, the items included in this scale, as well as the frequencies and percentages of respondents answers are displayed.

England

The respondents' answers to the items addressing this area reveal two distinct tendencies reflecting the different attitudinal sub-dimensions included under this heading. On the one hand, Item 9 yielded a considerable percentage of rejection (almost 80%), suggesting that the vast majority of English teachers attach little importance to having their pupils practising basic skills. On the other, the responses to Item 7, Item 17 and Item 19 suggest that on average (the percentage of endorsement or rejection ranges from 51% to 57%) the English teachers are favourably disposed towards a *constructivist* view of pupils' mathematical learning. Two considerations should be made concerning the answers to these three items. First, the high percentage of respondents opting for the uncertain category it is remarkable. Second, the inter-items correlations are in some cases relatively small (although statistically different from zero) suggesting little consistency across their answers to the three items. These considerations suggest that perhaps teachers' perceptions with regard to the *transmission/constructivist* dimension of pupils' mathematical learning need to be sharpened.

Portugal

The picture one gets from the Portuguese teachers' answers to the items addressing the area under scrutiny is, once again, not clear. At first glance, responses to Item 7 and Item 17 seem to indicate that the Portuguese teachers strongly endorse the notion that children can be agents of their own learning. In particular, in the case of Item 17 which expresses a moderate form of that idea, the percentage of respondents who agreed or strongly agreed with it was over 85%. Responses to Item 19, however, shed a different light on the previous picture. Indeed, about 70% of the Portuguese teachers indicated agreement with this item which states that "Most pupils learn maths better by attending to teacher's explanations than by being left to make things for themselves". Such variability in the kind of opinions expressed suggests that while the idea of pupils' constructing their mathematical knowledge might appeal to the Portuguese teachers, this might be still deemed a relatively uncertain means of achieving the curriculum objectives as compared to the traditional methods of teaching/learning based upon a transmission paradigm.

Table 5.7: Frequencies and percentages* of the responses (on a scale of 1-5) to the items included in the *Nature of learning mathematics* attitudinal area (in England and in Portugal)

	England					Portugal				
	<i>Strongly disagree</i>		<i>Strongly agree</i>		Missing	<i>Strongly disagree</i>		<i>Strongly agree</i>		Missing
	1	2	3	4		1	2	3	4	5
7. Expecting pupils to discover mathematical ideas by themselves is unreasonable	97 <i>16.8</i>	235 <i>40.7</i>	68 <i>11.8</i>	149 <i>25.8</i>	2 <i>5.0</i>	200 <i>17.4</i>	582 <i>50.6</i>	124 <i>10.8</i>	210 <i>18.2</i>	35 <i>3.0</i>
9. Most of the time in a maths lesson should be spent with pupils practising the basic mathematical skills till they master them	203 <i>35.3</i>	253 <i>44.0</i>	37 <i>6.4</i>	70 <i>12.2</i>	5 <i>2.1</i>	44 <i>3.8</i>	336 <i>29.2</i>	140 <i>12.2</i>	501 <i>43.6</i>	128 <i>11.1</i>
17. With little guidance most pupils should be able to discover most mathematical ideas for themselves	33 <i>5.7</i>	141 <i>24.4</i>	103 <i>17.8</i>	238 <i>41.2</i>	2 <i>10.9</i>	3 <i>0.3</i>	73 <i>6.3</i>	93 <i>8.1</i>	787 <i>68.2</i>	198 <i>17.2</i>
19. I think that most pupils learn maths better by attending to teacher's explanations than by being left to make sense of things for themselves	107 <i>18.1</i>	208 <i>36.2</i>	116 <i>20.2</i>	126 <i>22.0</i>	6 <i>3.5</i>	29 <i>2.5</i>	185 <i>16.1</i>	137 <i>11.9</i>	532 <i>46.3</i>	266 <i>23.2</i>

* Numbers in *italics* represent percentages, whereas numbers in plain text format represent frequencies

Equally unclear is the Portuguese teachers' standpoint about the *instrumental* versus *relational* perspective of pupils' learning. Approximately 55% of the respondents appear to believe that the focus of mathematics lessons should be on having pupils to practise basic skills (Item 9), whereas only about 34% rejected this idea. The relatively moderate majority of respondents endorsing this item together with the lack of other items addressing the same issue makes it extremely hazardous to suggest that the Portuguese teachers tend to have an instrumental view of pupils' mathematical learning.

Cross-country comparison

Differences between the two countries in the percentages of respondents endorsing or rejecting the items addressing this area ranged from moderate (about 8 percentage points) to very large (over 40 percentage points). The most notable difference concerned the extent to which the respondents endorsed Item 9 stating that "Most of the time in a mathematics lesson should be spent with pupils practising the basic mathematical skills until they master them". It does seem that as a result of recommendation, advice and directives on what and how primary mathematics should be taught, the vast majority of English teachers have broadened their opinions about the range of approaches and activities for children learning mathematics.

Given the rather diffuse picture obtained in Portugal, the contrast between the perceptions of the Portuguese and English teachers with regard to the sub-dimension imparted knowledge versus construction of mathematical knowledge is more difficult to draw. It is true, however, that there were substantial differences in the ways the teachers in the two countries answered two of the items addressing this dimension. Indeed, the percentage of teachers endorsing Item 17, which affirms that "With little guidance most pupils should be able to discover most mathematical ideas for themselves, is considerably higher (about 35 points) in Portugal than in England. This stands in marked contrast with the respondents' answers to Item 19, which states that "Most pupils learn maths better by attending to teacher's explanations than by being left to make sense of things for themselves". On this item, a difference of 45 points separates the opinions of the Portuguese and of the English respondents, with the former group expressing clear preference for a *transmission* paradigm of pupils' learning. This striking contrast may be related to the fact that the ideas that form the basis for the area under scrutiny are difficult to operationalise.

The teaching milieu

The five items initially included in this scale as well as the frequencies and percentages of answers to each of these items are shown in Table 5.8.

Table 5.8: Frequencies and percentages* of the responses (on a scale of 1-5) to the items included in the *The teaching milieu* attitudinal area (in England and Portugal)

	England					Portugal						
	Strongly disagree 1	Strongly disagree 2	3	Strongly agree 4	Strongly agree 5	Missing	Strongly disagree 1	Strongly disagree 2	3	Strongly agree 4	Strongly agree 5	Missing
6. In my maths lesson, I generally let pupils do whatever maths interests them.	68 29.2	328 56.9	39 6.8	34 5.9	7 1.2	4	62 5.4	512 44.7	181 15.8	364 31.8	26 2.3	15
10. In my maths lessons, pupils are used to discussing their own ideas and suggestions	53 0.7	77 9.3	322 13.0	116 56.6	11 20.4		16 1.5	172 16.0	135 12.6	657 61.1	95 8.8	85
11. Work in my maths lessons follow the textbook/workcard closely	123 21.4	249 43.4	73 12.7	119 20.7	10 1.7	6	86 7.5	490 42.7	106 9.2	431 37.5	35 3.0	1
15. As a rule, in my maths lessons, I encourage pupils to work in a co-operative way	3 0.5	29 5.1	32 5.6	305 53.2	204 35.6	7	9 0.8	147 12.7	100 8.7	739 64.0	160 13.9	5
16. In my maths class, I generally demonstrate procedures and methods for performing mathematics tasks.	52 9.1	189 33.2	84 14.8	208 36.6	36 6.3	11	2 0.2	31 2.7	49 4.3	733 63.7	335 29.1	10

* Numbers in *italics* represent percentages, whereas numbers in plain text format represent frequencies

England

The figures show different tendencies which reflect the four different aspects of the teaching milieu addressed by the items. First, in relation to pupil-pupil relationships, the English respondents appeared to be strongly in favour of cooperative work (Item 15) and of having pupils engaged in discussing mathematical ideas (Item 10). For example, the idea of having pupils working cooperatively in mathematics lessons appears to appeal to about 89% of the respondents. The heavy endorsement of the active role of pupils in mathematics lessons notwithstanding, the English teachers rejected the idea of classroom control being taken from their hands (Item 6). In turn, responses to Item 16, which concerns the way teachers perceive their own role in managing the teaching of mathematics, show a bi-polarisation of opinions with 42% of the respondents being in favour of the a *facilitator role* and with other 42% of the respondents favouring a *role model*. The relatively high percentage of uncertain answers to this item may be interpreted as a sign that teachers see their role depending on the specific content to be taught and the circumstances in which it is taught.

Portugal

There are several notable features reflected in the answers given by the Portuguese teachers to the five items addressing this area. The most striking result is the massive endorsement of Item 16 (about 93%) indicating that the vast majority of the respondents "generally demonstrate procedures and methods for performing mathematical tasks". Despite this strong tendency towards a teacher/subject-matter centred approach, the Portuguese teachers also subscribed to a great extent instructional strategies that emphasise active participation of pupils. For example, about 78% of the respondents agreed or strongly agreed that they encourage pupils to work cooperatively (Item 15) and about 70% of them endorsed Item 10 affirming that their "pupils are used to discussing their own ideas and suggestions".

Cross-country comparison

Differences between in the English and Portuguese teachers' answers to the items dealing with the teaching milieu were rather large. That is, the responses to the items on this scale, more than those on any of the others, appear to reflect the culture in which both teacher and school operate. Such differences may seen in the light of the different political and socio-economic conditions of the two countries with deep roots in the past which, in turn, are reflected in the disparity of the contexts of primary schools in England and in Portugal (e.g. size, resources, equipments, administration).

Of course, the differences in the perceptions of the teachers in the two countries of what (school) mathematics is about are most likely to have a considerable resonance on their opinions about the conditions that should be created for the teaching of the subject. For

example, consistent with a rule-oriented perspective of mathematics, the respondents in Portugal were more likely than those in England (by about 50 percentage points) to see their role as that of a demonstrator or model to follow (Item 16). It seems, however, that this role is not of the *dictatorial* type. Indeed, the percentage of Portuguese teachers who agreed or strongly agreed with the notion that they "let pupils do whatever maths interests them" was rather high, about 25 points higher than that of the English respondents. The rejection of the authoritative teacher-pupils relationships might above all reflect ideals of democracy in schools generated after the political revolution of 1974 in Portugal.

Evidence of a more *rigid* teaching milieu in the Portuguese classrooms than in the English ones was further obtained through the teachers' answers to Item 10, suggesting a higher reliance on the authority of the textbook on the part of the Portuguese teachers (with a difference of about 20 percentage points). Moreover, there is a considerable difference in the teachers' answers to the items concerning pupil-pupil relationships. For example, in relation to Item 15, which expresses the idea of a teaching milieu in which cooperation among pupils as opposed to competition prevails. Indeed, the Portuguese teachers were less likely, by a margin of 10%, than the English teachers to endorse such item. Several reasons may account for this difference. First, it is possible that in many cases the physical conditions of the classrooms place some constraints on a type of organisation in which group and cooperative work is encouraged. Second, it may be that an overemphasis on basic skills and techniques leaves little room for cooperative work and discussion among pupils. Finally, the pressure on test results and achievement may also play a determinant role.

Role of computers in mathematics lessons

The frequencies and percentages of the teachers' answers to the four items addressing this area are presented in Table 5.9.

England

The English teachers' responses to the items concerning this area show two major tendencies. On the one hand, the figures appear to show that a vast majority of the respondents were favourably disposed towards the use of computers in their mathematics lessons and believe that computers can contribute to making pupils' mathematical learning more exciting (Item 8, Item 12 and Item 18). On the other hand, the English respondents tended to endorse Item 14 affirming that "computers are especially useful in allowing children to practise mathematical skills". Such a tendency may indicate that only a minority of the respondents have been exposed to the most creative kind of software associated with problem solving and exploration of mathematical ideas.

Table 5.9: Frequencies and percentages* of the responses (on a scale of 1-5) to the items included in the *Role of computers in mathematics lessons* attitudinal area (in England and Portugal)

	England					Missing	Portugal					
	Strongly disagree 1	2	3	Strongly agree 4	5		Strongly disagree 1	2	3	Strongly agree 4	5	
8. Computers in a maths class will take up take up a lot of the pupils' time, effort and imagination which they could put into something else	189 32.8	270 46.9	68 11.8	39 6.8	10 1.7	4	184 16.2	404 35.6	390 34.4	122 10.7	35 3.1	25
12. I believe computers will make mathematics teaching more exciting	8 1.7	70 12.1	91 15.7	277 47.9	132 22.8	2	12 1.0	41 3.6	240 20.9	533 46.5	321 28.0	13
14. Computers are especially useful in allowing children to practise mathematical skills	46 8.0	114 19.8	109 18.9	237 41.1	71 12.3	3	44 3.9	187 16.5	363 32.0	442 38.9	99 8.7	25
18. Computers in a maths class can make it easier for pupils to work collaboratively.	14 2.4	80 13.8	121 20.9	285 49.3	78 13.5	2	11 1.0	86 7.6	441 38.8	453 39.9	145 12.8	24

* Numbers in *italics* represent percentages, whereas numbers in plain text format represent frequencies

Another feature of interest is related to the relatively high percentage of teachers who opted for the uncertain category in answering three of the four items included under this heading. Analysis of the cross-tables of these three items' answers by the dichotomous variable related to the use of computers in mathematics lessons suggests that the high percentage of uncertainty is associated with those teachers who are not using the computer in their mathematics lessons. Thus, the high percentage of *uncertain* answers may be attributed to the fact that computers are a new tool in education and therefore many respondents do not have a definite attitude towards them yet. In addition, it is possible that such a high percentage of *uncertain* answers is due to a certain ambiguity conveyed by the wording of the items.

Portugal

The most salient characteristic of the Portuguese teachers' answers to the items included under this heading is the high percentage of uncertainty exhibited (oscillating between about 21% and 39%). Also remarkable is the high number of missing answers to these items. Undoubtedly, these percentages and numbers reflect the fact that the use of computers in Portuguese primary schools was still embryonic and therefore the information about computers in mathematics was available only to a minority of Portuguese teachers. For some Portuguese respondents, the idea of having a computer in their schools is little more than ludicrous. In fact, some interesting comments were obtained in response to the question asking about whether or not computers were available in their schools. For example, one teacher commented: "Technology didn't arrive in this part of the country yet". Another teacher was still more resentful in her comment: "We have neither computers nor even a chair in which I can sit".

Nevertheless, the majority of respondents were able to commit themselves to an endorsement or rejection of the opinions expressed by the items. Overall, the respondents tended to show acceptability of the use of computers in their mathematics lessons and regard them as useful tools for pupils learning mathematics (Item 8, Item 12 and Item 18). It may be that the use of computers both in offices and homes is spreading so rapidly that they feel encouraged to use them in schools as well. On the other hand, the Portuguese respondents tended to endorse to a great extent the use of the computer as a calculator device (Item 14).

Cross-country comparison

Interestingly, the overall pattern of responses of the Portuguese teachers to the items addressing this area was similar to that of the English teachers. In fact, in both countries the results show two major tendencies. First, the majority of respondents appear to be in favour of incorporating computers into their mathematics teaching (Item 8, Item 12, and Item 18). Second, the respondents in both countries tended to endorse Item 14, thus agreeing with the proposition that computers are especially useful for pupils to practise mathematical skills. That

is, in both countries the respondents tend to think of the computer more as a *curriculum supporter* or *curriculum modifier* than as a *change agent*. (As a matter of fact, Item 14 correlates negatively with the other three items, and should therefore be interpreted separately as an indication of a totally different dimension underlying teachers' attitudes towards the use of computers in mathematics lessons).

The cross-country similarities notwithstanding, there was a major difference in the degree of uncertainty shown by the respondents in the two countries. Not surprisingly, the percentages of respondents who opted for the *uncertain* category is considerably higher in Portugal than in England. The main reason for that is that the Portuguese teachers have been far less exposed to information about computers in education than their counterparts in England. The most striking difference concerns the proportions of teachers in the two countries who showed uncertainty regarding Item 8 stating that computers will take much of pupils' time, effort and imagination which could be put into something else. While in England this item was that yielding the least percentage of *uncertain* answers, in Portugal it yielded the second highest number of undecided respondents. The existence in Portugal of a national prescribed curriculum which already takes much of the pupils' time and effort may partially account for the Portuguese teachers' reluctance to commit to a definite position.

Scales summary scores analysis

As an extension of the preceding analyses of the respondents' attitudes towards mathematics and mathematics teaching, this sub-section presents a series of results concerning those attitudes which emerged from the analysis of the scales scores. The analysis of the summary scores was only carried out on five of the eight attitudinal scales initially considered: *Nature of mathematics*, *Mathematics as a subject*, *Mathematics and oneself (in the present)*, *Nature of learning mathematics*, and *Role of computers in mathematics lessons*. To avoid repetition, I try to concentrate on those issues of the greatest significance from a cross-country vantage point.

Table 5.10 displays for both countries the means, standard deviations and the standard errors of the means of the scores on those five attitudinal scales. Standard error of the means are included to indicate approximate levels of the sampling error for comparisons on the different scales. (As stated in Chapter 3, the scales summary scores were computed taking into consideration only the items which were found to discriminate well in both countries. When the number of common discriminating items contributing to an attitude scale fell below three, no summary scores were calculated).

Table 5.10: Mean scores, standard deviation and standard error of the means on five scales summary scores for respondents (in England and in Portugal)

	Nature of mathematics (3)*		Mathematics as a subject(3)*		Mathematics and oneself (4)*		Nature of learning mathematics (3)*		Computers in mathematics (3)*	
	Mean	Standard	Mean	Standard	Mean	Standard	Mean	Standard	Mean	Standard
	Score	Deviation	Score	Deviation	Score	Deviation	Score	Deviation	Score	Deviation
England	9.5	2.3	10.5	2.2	13.4	3.7	10.8	2.4	11.4	2.3
	<i>0.10**</i>		<i>0.09**</i>		<i>0.15**</i>		<i>0.10**</i>		<i>0.09**</i>	
Portugal	7.2	2.1	10.2	2.1	14.2	3.2	8.6	2.2	11.1	2.1
	<i>0.06**</i>		<i>0.06**</i>		<i>0.10**</i>		<i>0.07**</i>		<i>0.06**</i>	

* Numbers in brackets report the actual number of items contributing to the corresponding attitude scale.

** Numbers in italics report the standard error of the mean

There are some interesting features about the results reported in Table 5.10. Overall, they suggest that the differences between the English and the Portuguese teachers' attitudes are more marked than the similarities. One of the most startling difference concerns the lower standard deviations associated with the attitude scores means of the Portuguese respondents. This suggests that the differences of attitudes were less pronounced among this group of teachers than among the English ones. Three speculative explanations can be offered for the lower variability of opinions among the Portuguese respondents. First, a very standardised type of teacher-training programme, as well as the lack of opportunities for teachers extending their initial preparation may well lead to more stereotyped attitudes among the Portuguese teachers than among the English ones. Second, the existence of a national curriculum in Portugal may contribute to less variation of opinions among the Portuguese teachers. Third, it is normally accepted that people in industrialised countries are more likely to value individualism and individual differences than in less industrialised ones. This may well lead to a lower degree of socialisation of teachers in England than in Portugal and therefore to less uniformity of opinions.

The results in Table 5.10 also point to considerable differences in the scales means scores. As already stated in Chapter 3, these differences are probably best interpreted if one takes into account the patterns of the profiles of mean scores of the various scales (see Figure 5.1). As can be seen, while the Portuguese teachers produced the highest mean score on the *Mathematics and oneself* scale, the English teachers presented the highest mean scores on the remaining attitude scales. These are notable differences, and it is important to search out their sources. For example, why do the Portuguese teachers appear to feel more confident with mathematics and more fond of the subject than the teachers in England? Why do the teachers in England think of mathematics as a more informal and flexible body of knowledge than their counterparts in Portugal?

One may wonder, for example, whether the contrasted relationship between the respondents' feelings towards mathematics and their views about the subject reflects the fact that teachers who express an absolutist view of mathematics are more likely to enjoy and feel confident with the subject than those who see the subject as an open and flexible field. Such explanation is, however, precluded since the correlations between the two attitudinal scales scores (*Mathematics and oneself*, and *Nature of mathematics*) within the same country are considerably low. One has then to interpret that contrasted relationship in the light of other explanations, and two come to mind. First, it is important to be aware of the possibility that respondents give socially acceptable answers, and that what is socially acceptable may differ from country to country. If that is the case, then the English respondents' willingness to appear boastful about their professional prowess leads them to endorse views of mathematics as an open and flexible system, and opinions about children's mathematical learning that emphasise problem solving and require the active pursuit of knowledge by pupils. In turn, liking mathematics and showing confidence with it are the most socially acceptable attributes among the Portuguese teachers. The second possibility is that the factors that contribute to 'real' differences in the respondents' attitudes are idiosyncratic to the countries. For example, one may speculate that the fact that the Portuguese respondents seem to enjoy and feel more confident with mathematics is associated with their highest qualifications in mathematics. In turn, the prevalence of a perspective of mathematics as a creative subject and of constructivist views of pupils' mathematical learning among the English respondents could be seen in the light of their higher participation in in-service courses in mathematics education.

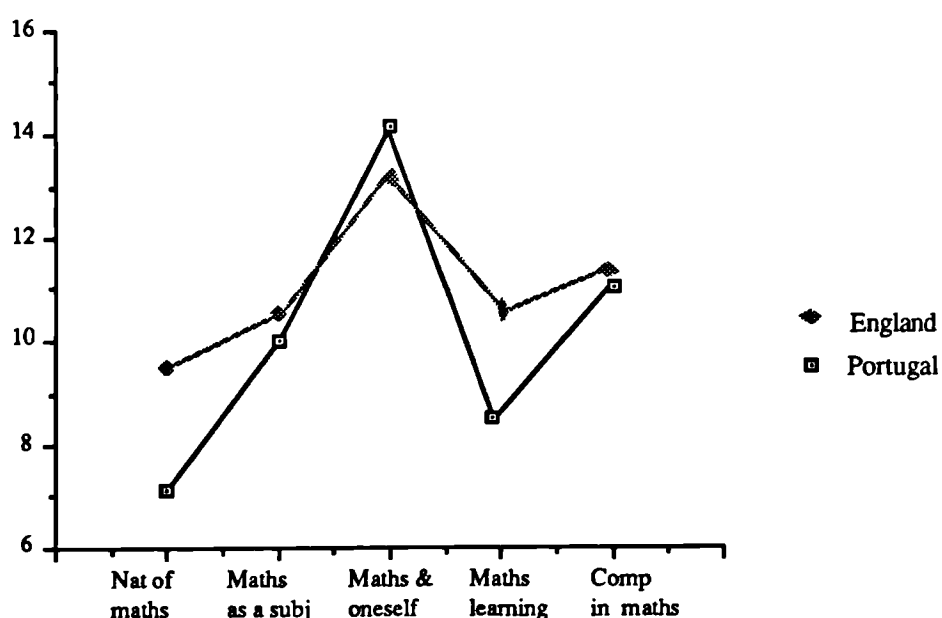


Figure 5.1 Means profiles on five attitudinal scales summary scores

Another interesting feature highlighted by Figure 5.1 concerns the mean scores on the *Mathematics as a subject* on the *Nature of mathematics* scales. In both countries, the mean scores on the latter scale are lower than the mean scores on the former one, thus suggesting that it is possible to hold a *formalist* and *fixed* view of mathematics, and at the same time to perceive school mathematics as a creative, open-ended subject. Of greater interest is that the difference between the mean scores in the two scales is higher in Portugal than in England. A possible explanation for this is offered. The English teachers' views about mathematics may have been perturbed as a result of their acquired views about school mathematics. For the Portuguese teachers, in contrast, their perceptions of school mathematics are likely to be most influenced by an *absolutist* perspective of mathematics resulting partly from the way in which they have learned the subject, as well as from the *formalist* orientation of the primary school curriculum (strongly embedded of a 'new-maths' flavour).

Finally, it is interesting to note the similar patterns of the mean scores on the *Mathematics as a subject* and *Role of computers in mathematics lessons* scales on the one hand, and on the *Nature of mathematics* and *Nature of learning mathematics* on the other. One may speculate about the idea that the acceptability of the use of computers in mathematics lessons is associated with the view of school mathematics as a creative and dynamic subject (but bears no relationship with teachers' views about the nature of mathematics). In turn, it would seem that teachers' views about how pupils' mathematics learning takes place tended to be associated more with their views about the nature of mathematics than with their perspectives about school mathematics. However, correlation coefficients among the attitudinal scores do not give support to this suggestion. I cannot offer an alternative explanation for the similar patterns, but the finding is certainly of enough interest to place the issue on the agenda of further research.

EXPLORING RELATIONSHIPS BETWEEN THE RESPONDENTS' ATTITUDES TOWARDS MATHEMATICS AND MATHEMATICS TEACHING AND BACKGROUND VARIABLES

Having examined the respondents' attitudes towards mathematics and mathematics teaching and the influence of culture variations on those attitudes, attempts were made to address a subsidiary research aim: that of exploring eventual relationships between teachers' attitudes and background variables (within the same country). As already stated in Chapter 3, the method employed for this purpose was that of multiple regression analysis. Stated briefly, the method aims at predicting or explaining the 'influence' of several independent variables on one dependent (or criterion) variable. Thus, separate multiple regression analyses were carried out for each of the following six attitudinal scales (and for each country): *Nature of mathematics*,

Mathematics as a subject, Mathematics and oneself (in the present), Nature of learning mathematics, The teaching milieu, and Role of computers in mathematics lessons.

Appendix B.2 presents some considerations as to the choice of the independent variables and to the ways in which those analyses were carried out. In addition, it also provides an example illustrating how these analyses led on to explain the variability of teachers' attitudes. In this section, some selected results are presented and discussed. The selected nine variables were grouped into three main categories or levels: Level I -- Biographical variables (*Age; Sex*); Level II -- Teachers' academic and professional experiences (e.g. *Highest mathematics qualifications; Initial academic qualifications; Length of primary teaching experience*); and Level III -- 'Special' professional experiences (corresponding to the two study main variables: *Attendance at in-service courses in mathematics education, and Use of computers in mathematics lessons*).

Table 5.11 and Table 5.12 provide a summary of those results of the different regression analyses undertaken. They display the variations in attitudes scores on those six scales accounted for by the selected variables corresponding to two different orders of entry of the variables respectively in England and Portugal. (The identification of these variables are given in the footnotes of the tables).

The major predicament in carrying out such analyses came from the fact that the selected independent variables explained very little of the variance of the attitudinal scales scores even when all the variables were considered together. As the figures in Table 5.11 and Table 5.12 show, in England, the variance explained ranged from about 7% (for the *Nature of mathematics* scale) and 26% (for the *Mathematics and oneself* scale). In Portugal, it varied from 1% (for the *Nature of mathematics* scale) and 9% (for the *Nature of learning mathematics* scale). While I was aware that I had left out some important psychological variables (e.g. personality), I was somehow disappointed in finding the limited significance of the variables considered. One can speculate that these results arose for a number of reasons. First, there were other crucial variables associated with teachers' attitudes towards mathematics and mathematics teaching which had been initially considered but that were discarded in the analysis (e.g. school related variables). Second, as already suggested, the scales used were but rough indices of teachers' attitudes. Finally, the influence of background variables on teachers' attitudes towards mathematics and mathematics teaching may be too complex and elusive phenomena to be studied through paper and pencil instruments. In Portugal, the extremely small amount of variance explained by the independent variables can be attributed further to the relative uniformity of opinions among teachers (associated with both the existence of a national curriculum and uniformity of teacher training experiences).

Table 5.11: Variance in the summary scores of six attitudinal scales accounted for by selected variables corresponding to two different models (Model 1 and Model 2)*** of the regression equations (in England)**

	Mathematics and oneself		Nature of mathematics		Mathematics as a subject		Nature of learning mathematics		The teaching milieu		Computers in mathematics	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
<i>Level I</i>												
X1	---	---	.050	.050(1)	.010	.009 (6)	.012	.000 (7)	.017	.002 (4)	---	---
X2	.030*	.004 (2)	---	---	---	---	---	---	---	---	---	---
<i>Level II</i>												
X3	.132	.154(3)	---	---	.027	.012 (5)	.026	.014 (5)	---	---	---	---
X4	---	---	.003	.002(3)	.016	.020(4)	.013	.015(2)	.022	.018(2)	---	---
X5	---	---	---	---	---	---	---	---	---	---	.016	.007 (3)
X6	---	---	.004	.004(2)	---	---	.003	.015(6)	.004	.013(3)	---	---
X7	.080	.083(4)	---	---	.057	.064(1)	.015	.011 (4)	.029	.021(4)	.009	.005 (4)
<i>Level III</i>												
X8	.016	.017(1)	---	---	.030	.040(2)	.056	.068(1)	.044	.062(1)	.009	.007 (2)
X9	---	---	.011	.011(4)	.008	.004 (3)	.007	.009(3)	.005	.005 (5)	.084	.099(1)
Total for all variables	.258	.258	.067	.067	.149	.149	.132	.132	.121	.121	.118	.118

* Boldface indicates a variation that is statistical significant at 0.05 level.

** X1: Age; X2: Sex; X3: Highest mathematics qualifications; X4: Initial academic qualifications; X5: Other teaching experience;

X6: Length of primary teaching experience; X7: Posts of responsibility related to teaching; X8: Attendance at in-service courses in mathematics education; X9: Use of computers in maths lessons.

*** Numbers in brackets represent the order of entry of the variables in Model 2; in Model 1 the variables were entered in the order in which they are displayed.

Table 5.12: Variance in the summary scores of six attitudinal scales accounted for by selected variables corresponding to two different models (Model 1 and Model 2)*** of the regression equations (in Portugal)**

	Mathematics and oneself		Nature of mathematics		Mathematics as a subject		Nature of learning mathematics		The teaching milieu		Computers in mathematics	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
Level I												
X1	---	---	.006	.050(2)	---	---	.047	.006(2)	---	---	.008	.000(3)
X2	.012*	.012(3)	---	---	.017	.017(1)	.005	.003 (6)	.009	.002(3)	.015	.012(2)
Level II												
X3	.019	.009 (2)	---	---	.012	.012 (2)	.012	.008 (4)	---	---	---	---
X4	.014	.024(1)	---	---	---	---	.016	.063(1)	.014	.021(2)	.009	.020(1)
X5	---	---	---	---	---	---	---	---	.021	.021(1)	---	---
X6	---	---	.000	.000 (3)	---	---	.001	.001(3)	---	---	.000	.000(4)
X7	---	---	.007	.008(1)	---	---	---	---	---	---	---	---
Level III												
X8	---	---	---	---	---	---	.007	.007(5)	---	---	---	---
Total for all variables	.045	.045	.013	.013	.029	.029	.087	.087	.044	.044	.032	.032

* Boldface indicates a variation that is statistical significant at 0.05 level;

** X1: Age; X2: Sex; X3: Highest mathematics qualifications; X4: Initial academic qualifications; X5: Other teaching experience; X6: Length of primary teaching experience; X7: Posts of responsibility related to teaching; X8: Attendance at in-service courses in mathematics education.

*** Numbers in brackets represent the order of entry of the variables in Model 2; in Model 1 the variables were entered in the order in which they are displayed.

The very small variance of the attitudinal scores explained by the independent variables suggests that discussion of the results for the Portuguese teachers hardly deserves any further consideration. It will be, therefore, omitted. In England, the results are not very gratifying either, and probably would justify similarly dismissing treatment. However, to convey some sense of the analyses undertaken and because it is my conviction that the results may bring some enrichment to an area that has been so poorly studied, it might be helpful to report them here. Obviously, there will be no room to raise issues of comparability of teachers' attitudes in both countries in terms of factors considered.

In what follows, the relationships between the chosen independent variables and the English respondents' attitudes are reported and discussed. The discussion is presented in three different sub-sections corresponding to the three categories of selected explanatory variables.

Influence of biographical variables on the respondents' attitudes

Obviously, neither of the two variables included under this heading (*age* and *sex*) may be seen as influenced by the respondents' attitudes. The direction of any eventual relationship between these teachers' characteristics and their attitudes seems clear. However, characteristics such as age and sex are most likely associated with other variables that may regulate or be regulated by teachers' attitudes. To cite one example, age is significantly correlated with the type of initial academic qualifications held by teachers. Therefore, if a relationship between age and teachers' attitudes is discovered, this might be attributed, at least in part, to their different academic experiences. With such kinds of interactions, the mechanisms of causality become less transparent.

Age

As can be seen in Table 5.11, Age contributes some variance to the attitude scores in four of the attitude scales: *Nature of mathematics*, *Mathematics as a subject*, *Nature of learning mathematics* and *The teaching milieu*. However, the effect of the variable on the two latter attitude scales scores is not significant when it is entered in the regression equation after the correlated variable *Length of primary teaching experience*. For that reason, the discussion of the results is limited to the influence of teachers' age on the former two attitude scales scores.

Age tends to be negatively correlated to those scores, that is, the older the teachers the lower their scores in the two scales. In other words, the older the teachers the more likely they have a *formalist* and *fixed* view of mathematics, and the less they tend to regard school mathematics as a subject providing opportunity for creative and open-ended work. This kind of relationship may be said expected. In fact, the older the teachers the more likely they were exposed in past

to traditional mathematics. Moreover, this is in line with the commonly-accepted view that older people tend to be relatively reluctant to new ideas.

It is also important to note that age does not appear to have any relationship with the respondents' scores on the *Mathematics and oneself* scale. Apparently, feelings of enjoyment for and confidence with dealing with mathematics or their opposites are likely to occur in teachers of any age.

Sex

Sex only contributes a negligible amount of variance to the respondents' scores in the *Mathematics and oneself* attitude scale (see Table 5.11). On the whole, the male teachers seem to feel more confident with and enjoy more mathematics than the female teachers. This result is in agreement with existing literature about women (in general) and mathematics suggesting that females' self-concepts about their ability in mathematics is less positive than that of males. Of course, the fact that mathematics has been traditionally considered a domain in which men typically have greater interest and ability may have led the male respondents to express more 'favourably' than the female ones about their feelings about mathematics because this was the 'acceptable' way of behaving.

Apart from this association of the variable with the respondents' feelings towards mathematics there are no sex-related differences. This is a relevant finding suggesting that teachers' views about mathematics and school mathematics, as well as their attitudes towards the teaching of the subject are not affected by sex-role stereotyping. It seems that although female teachers may have lower self-concepts about their mathematical ability, they tend not to project these stereotyped attitudes and expectations when dealing with their pupils.

The respondents' academic and professional experiences and their attitudes

As the figures in Table 5.11 show, with the exception of the *Other teaching experience* variable, all the other variables included in this group (*Highest qualifications in mathematics*, *Initial academic qualifications*, *Length of primary teaching experience*, and *Posts of responsibility related to teaching*) contribute some variance to two or more of the attitudinal scales scores. The association between these variables and the respondents' attitudes is likely to be more complicated than in the previous case. In fact, although it is logically defensible to view these variables as exerting some influence on the respondents' attitudes, one cannot overlook the effect of their attitudes on those variables either (with the possible exception of the *Length of primary teaching experience* variable).

Highest qualifications in mathematics

The participants' highest qualifications in mathematics is related to the respondents' scores in the *Mathematics and oneself* scale accounting for more than half of its explained variance (see Table 5.11). The relationship is the expected one. The respondents with A-level or equivalent in mathematics are among those who most enjoy and feel confident in dealing with mathematics. In turn, those who do not have any formal qualifications in mathematics are among those who showed the least enjoyment of and confidence with the subject. Of course, the direction of causality of relationship is equivocal. People's feelings towards mathematics can be concomitantly a strong influence in their decision to pursue or avoid further mathematics and a reflection of the kinds of mathematics they were exposed to.

The respondents' highest qualifications in mathematics are also associated with their views about school mathematics (*Mathematics as a subject* scale scores) and their perceptions of how best children's mathematical learning takes place (*Nature of mathematics learning* scale scores). However, as can be seen in Table 5.11, the contribution of this variable on those two scores is not significant when entered in the corresponding equations after other teaching related variables (e.g. *Initial academic qualifications*). Moreover, the fact that the standard error of the regression coefficients associated with the factor under consideration are considerably high makes it risky to suggest the type of the existing associations.

Initial academic qualifications

As Table 5.11 shows, the participants' initial academic qualifications is associated with their attitudes with regard to four of the six attitudinal areas considered: *Nature of Mathematics*, *Mathematics as a Subject*, *Nature of Learning Mathematics* and *The Teaching Milieu*. (The association of the variable with the teachers' views about the nature of mathematics is, however, negligible). Like in the previous case, however, it was not possible to tease out the association of the scores with particular groups of respondents corresponding to a certain type of teacher training. This may be due to the fact that teachers' initial qualifications are highly correlated with some of the other variables (e.g. age, initial qualifications in mathematics).

Length of primary teaching experience

This variable is negatively related to the respondents' scores on the *Nature of Mathematics*, *Nature of mathematics learning* and *The teaching milieu* scales. The contribution of the variable, however, is non significant when the variable is entered after the variable *Age* (see Table 5.11). This does not cast doubt on the common sense view, supported in part by the results of the separate regression analyses performed with these two independent variables, that the variable *Length of primary teaching experience* is probably more important than the variable

Age (at least as far as teachers' opinions about children's mathematical learning and the teaching milieu are concerned).

Posts of responsibility related to teaching

Table 5.11 shows that the variable under consideration is associated with the respondents' scores on the following attitudinal scales: *Mathematics and oneself*, *Mathematics as a subject*, *Nature of learning mathematics*, *The teaching milieu* and *Computers in mathematics lessons*. The relationships may be said to be the expected ones, but, of course, they are by no means causal ones. The contribution of the variable seems to be most significant in the case of teachers' views of school mathematics. Those teachers who have been responsible for mathematics and/or computers scored the highest on the scale under consideration, that is, they were more likely to endorse a view of mathematics that is dynamic and creative than teachers in other categories. This may be associated with the fact that teachers who held positions of responsibility related to the teaching of mathematics and/or computers are, more than any other group of teachers, in touch with new ideas about mathematics education. Other teachers who also endorsed views of mathematics as a creative and open-ended subject are those who have held positions of head or deputy head of school.

A similar pattern of relationship is obtained with respect to the respondents' scores in *The Teaching Milieu* scale. In this case, however, the differences of the mean scores of those two groups of teachers are minor. This may be interpreted as an indication that teachers' views about the milieu for the teaching of mathematics should be seen in a broader context rather than a subject specific one.

The respondents' 'special' professional experiences and their attitudes

In a way that confirms my expectations, the two variables in this group (*Attendance at in-service courses in mathematics education* and *Use of computers in mathematics lessons*) make a relatively large contribution to the variance of the respondents' attitudinal scores (see Table 5.11). These findings are doubtless of most interest, although clearly one cannot infer any relation of causality. Since participation in in-service courses and the use of computers in mathematics lessons are voluntary, the motivation which leads teachers to participate in in-service and to use computers may vary. For example, it may be the case that the teachers with the most 'favourable' attitudes are those who tend to participate in in-service courses (this may be especially true in the case of participation in long courses). Nevertheless, these results give some support to the idea of encouraging the provision of opportunities for in-service training and the participation of teachers in it, as well as for the use of computers in mathematics

lessons. It may be that the involvement of teachers in these especial professional experiences are dependent on their attitudes, and that these, in turn, are influenced by those experiences.

Recent attendance at in-service courses in mathematics education

As the figures in Table 5.11 show, the variable under scrutiny appeared to bear significant relationships with the respondents' scores in three of the attitude scales: *Mathematics as a subject*, *Nature of learning mathematics*, and *The teaching milieu*. The study of the regression equation coefficients concerning these three attitudinal areas shows that both the number and the length of the in-service courses matter for teachers' attitudes. The highest scores in those three scales appear to be associated with teachers' participation in at least one long duration in-service course. That is, the teachers who have attended at least one long course tend to show a higher commitment to a perspective of school mathematics as a flexible, creative and innovative area of study, and to hold a more constructivist view of children's mathematical learning and be more problem solving oriented than the remaining teachers. Moreover, they are more likely to be in favour of *flexible* teaching strategies, with the teacher resorting to a variety of roles and using a variety of teaching materials, and pupils working together.

Use of computers in mathematics lessons

There seems to be a significant difference in the respondents' views about mathematics, as well as in their opinions about children's mathematics learning, and the role of computers in mathematics learning associated with whether or not they generally use computers in their mathematics lessons. Indeed, the results shown in Table 5.11 reveal that when the variable *Use of computers in mathematics lessons* is entered in the corresponding regression equations in last place, it still accounts for some variance of the scores. (Moreover, the variable adds a non-significant contribution to the variance of teachers' views about school mathematics and their opinions about the teaching milieu). Other factors kept constant, the teachers who generally use computers in their mathematics lessons are more inclined to: (a) view mathematics as an open system; (b) describe children's mathematical learning as emphasising problem solving and construction of mathematical knowledge; and (c) regard computers as increasingly central for fostering pupils' mathematical learning.

SUMMARY

This chapter has presented the results of the two sweeps of the primary teachers' attitude survey carried out in England and Portugal. Those results have been discussed in two different sections concerning: (1) the respondents' attitudes towards mathematics and towards

mathematics teaching in terms of various selected areas; and (2) the exploration of relationships between various background characteristics of the respondents, and their attitudes towards mathematics and mathematics teaching. Within the former section, the results have been presented from a cross-country vantage point. The second section has restricted the discussion to the English participants.

The results related to the respondents' attitudes have yielded both differences and similarities across the two countries. One of the most interesting differences concerns the issue of the variability of the respondents' attitudes in both countries. Reflecting among other things the uniform characteristics of primary teacher's training in Portugal and the existence of a national curriculum in this country, the variability of attitudes among the Portuguese respondents has been found to be considerably lower compared to that of their counterparts in England. It has also been interesting to find out that in spite of the markedly different characteristics of the respondents certain aspects of teachers' attitudes towards mathematics and mathematics teaching appear to cross cultural barriers. Such is the case of the respondents' opinions about the importance of mathematics. On the other hand, in virtually every one of the other attitudinal areas investigated there were substantial cross-country differences. These differences were specially striking with regard to the teachers' views about the *nature of mathematics*, and their opinions about the *teaching milieu* for the learning of mathematics.

The issue of the relationships between respondents' attitudes and their personal characteristics has been probably one of the most murky of all those studied. The main reason for this may be that the basis upon which this investigation was grounded was rather weak. It has been found that the selected background variables were a rather poor predictor of the respondents' attitudes, and this was especially so in the case of the Portuguese respondents. The discussion of relationships between the respondents' attitudes and their personal characteristics has been therefore restricted to the English respondents.

In terms of the implications of attitude survey results for the second sub-study, two points seem to be particularly significant. First, they indicate that the English teachers differ considerably from the Portuguese ones in their attitudes towards mathematics and mathematics teaching. Second, the enquiry has suggested that teachers' attendance at in-service courses in mathematics education and the regular use of computers in mathematics lessons (at least in England) are associated with their attitudes with regard to most of attitudinal areas considered.

CHAPTER 6

A motion picture of primary teachers' attitudes towards mathematics and mathematics teaching

(Findings of the attitude change sub-study)

This chapter is concerned with the findings of the second sub-study -- the attitude change sub-study having as a basis a Logo in-service course. The metaphor of *motion picture* is used to indicate the longitudinal nature of the sub-study, focusing as it does on the participants' attitudes over the period of the duration of the course.

The chapter is in two major parts. The first part deals with the cross-case findings of the sub-study. It attempts to describe and explain what appeared to be similar patterns of: (1) the participants' motives for joining the Logo course, and their initial attitudes towards mathematics, towards mathematics teaching and towards computers; (2) the participants' responses to and interactions with the course; and (3) the shifts in the participants' initial attitudes. The cases of the English teachers are examined conjointly with those of the Portuguese ones, but comparisons between the two groups are noted when the cross-country differences are judged to be of special interest.

In the second part, the *mini-portraits* of two English teachers and two Portuguese ones who participated in the Logo course are presented with the purpose of documenting how individual participants dealt with the affective and cognitive issues that they faced throughout the course, the main factors that informed their interactions and how their attitudes evolved. (Details of each of these four participants' attitudes and how these attitudes evolved throughout the course are presented in Appendix F.1 through Appendix F.4).

Before moving on into a characterisation of the participants' attitudes towards mathematics and mathematics teaching, and the evolution of these attitudes throughout the Logo course, a picture of some of the participants' background variables is presented. This aims to provide an integrated account to serve as a basis for the cross-case analysis that follow, as well as to

assess the extent to which the course participants differed from the populations surveyed in the first sub-study.

Introduction to the results

In England, the course participants were two female and five male teachers from seven London schools. Three of the participants (John, Joseph, Mark) were full-time teachers in junior schools, and two were full-time teachers in infant schools (David and Debbie). The other two participants were working as part-time teachers, one in a junior school (Katie) and the other (Paul) in a special school for children with behavioural problems. Their average age was 40.5 years. The number of years of primary teaching experience ranged from one to twenty-two, the mean being 8.6, and they have taught in their current schools for a period that ranged from less than one year to twelve years.

In Portugal, the participating teachers were ten females of average age 43.1. They came from six different schools of the Oporto area at which they have taught an average of 7.4 years. Their teaching experience ranged from eleven to thirty-eight years, the average being 22.8. One of the teachers (Joana) was working as a *Resource Person* in the same school of another two participants. Another participant (Emília) was teaching a group of mentally retarded pupils in a school for children with special needs. Another teacher (Clara) was working in a school annexe to a teacher training college and was in charge of the induction into teaching of a group of primary student-teachers. Two other participants (Laura and Tânia) coupled their work as teachers with the function of heads of their schools. The remaining five teachers (Alice, Ana, Diana, Rosa and Sara) were working in ordinary conditions in their schools.

In comparing the course participants' background variables with those of the teachers participating in the first sub-study, a few differences emerged. Such differences are probably related, at least in part, to the fact that in both countries the Logo course was held in a city and therefore the participants came from a narrow range of schools. Interestingly, the two groups of course participants differ from the teachers surveyed in the first sub-study in opposed directions. For example, in Portugal, the average age, length of teaching experience and length of service in present school of the course participants were higher than the ones of the teachers in the first phase of the study. In turn, the English teachers participating in the Logo course had much shorter teaching experience and have stayed in the same school lesser time than the teachers surveyed in the first sub-study, thus constituting a less stable professional group. A plausible explanation for that is that the English primary teachers (in contrast with the Portuguese ones) are likely to opt for alternative professions after some years of teaching, and these alternative are more available in a big city area than in an area predominantly rural.

Further noticeable differences between the course participants and the populations surveyed in the first sub-study are related to the variables *attendance at in-service courses related to mathematics* and *use of computers in mathematics lessons*. In Portugal, half of the course participants reported that they had recently attended in-service courses related to mathematics, a percentage considerably higher than the one found in the first sub-study. Furthermore, two of the course participants have been using computers with their pupils, fact that may be considered almost exceptional at the time. Once again, these differences may be attributed to the city/rural divide. In England, the percentage of the course participants who reported to have recently attended in-service mathematics courses was even less than in the case of the teachers participating in the first sub-study. This may be partly explained by the fact that the local educational authorities in Suffolk county council (where the attitude survey was administered) were developing a comprehensive advisory service in mathematics and computers education.

A further area of comparability between the course participants and the teachers participating in the first sub-study is in respect of their attitudes as assessed by the attitude questionnaire. Two of the differences between the attitudes of the participants in the two sub-studies may come to no surprise. First, the teachers who volunteered for the Logo course seemed to see more advantages in the use of computers in mathematics lessons (e.g. facilitate cooperation, make mathematics teaching more interesting) than the teachers participating in the first sub-study. Second, they were more likely to endorse views that characterise school mathematics as a changeable and creative subject than the population of teachers at large.

In Portugal, a further contrast between the attitudes of the participants in the two sub-studies was revealed. On the one hand, on the level of the teachers' conceptions of mathematics teaching, the course participants seemed more in favour of having children to explore mathematical ideas, and more inclined to create a classroom climate in which children could work cooperatively and take responsibility for their own work than the teachers surveyed in the first sub-study. On the other hand, the course participants tended to hold a more *formalist* view of mathematics than the teachers who participated in the attitude survey. The trend towards both a *formalist* view of mathematics and a *flexible* conception of mathematics teaching is consistent with the curriculum movement in Portugal, and may be attributable to the fact that the course participants constituted a group of outstanding teachers (at least, they belonged to the first wave of teachers who were 'interested' in introducing computers into their teaching) who enjoy to be in touch with the 'new' educational developments supposedly in the search for better schooling.

The differences noted (particularly in Portugal) notwithstanding, they are probably not fundamental to engender a feeling that the course participants bore no resemblance with the populations of teachers at large. To illustrate this point, it is important to emphasise that course participants' answers to the attitudinal items which were judged to reflect *national* trends (those items which within each country were either endorsed or rejected by more than 80% of the attitude survey respondents) are consistent with those trends (See Table 6.1). In particular, it is interesting to note that, following a pattern similar to that found in the first sub-study, the great majority of the Portuguese participants endorsed the view that "each mathematical problem generally has one best way to get the solution" whereas the great majority of the English ones rejected it.

Table 6.1: Number of the course participants endorsing or rejecting the questionnaire items that reflect *national* trends, in England and Portugal

<i>Items that reflect national trends</i>	<i>England(7)*</i>	<i>Portugal(10)</i>
Almost anybody can learn maths if it is properly taught	----	9(A)**
There is a fascination in studying maths irrespective of its usefulness	7(A)	---
Most of the maths I studied at school was a waste of time	----	9(D)***
Each maths problem generally has one best way to get the solution	6(D)	9(A)
With a little guidance most pupils should be able to discover maths for themselves	----	9(A)
In my maths lessons I generally let pupils do whatever maths interests them	5(D)	---
As a rule, in my maths lessons, I encourage pupils to work in a cooperative way	7(A)	----
In my maths class I generally demonstrate procedures and methods for performing mathematical tasks	----	10(A)

* numbers in brackets indicate the number of participants in each country		
** (A) = agreement or strongly agreement with the item		
*** (D) =disagreement or strongly disagreement with the item.		

Finally, another point is worth noting in considering the overall picture of the course participants in each country. As already stated in Chapter 3, the recruitment of the course participants in England was particularly difficult. Having realised that the public advertisement of the course was largely ineffective (only three teachers had volunteered for the course in response to such advertisement), I had to make efforts to recruit teachers directly in schools through face-to-face contacts. In Portugal, in contrast, the course was oversubscribed. Three major reasons can be found to explain the greater interest and participation in the Logo course in Portugal. First, it might be attributed to the novelty of computers in education in Portugal. A

second reason might have to do with the limited opportunities for the Portuguese teachers attending in-service courses similar to the Logo course. Thirdly, the fact that the Logo course in Portugal was endorsed by the MINERVA project might have also been critical in fostering the Portuguese teachers' interest in it.

CROSS-CASE FINDINGS

The discussion of the cross-case findings is in three episodes that trace the story of the participants' attitudes throughout the course. The first episode focuses on the participants' motives for joining the course, as well as on their initial (at the time they joined the course) attitudes towards: (a) mathematics; (b) mathematics teaching; and (c) computers. It aims to provide the background against which the participants' responses to and interactions with the course are examined. This examination is carried out in the second episode. Finally, the third episode reveals shifts in the participants' attitudes by both comparing their attitudes at the end of the course with those they held at the beginning, and taking into account their interactions with the course. Throughout the different episodes, flashbacks and foresights are often used to bring clarity and dynamism to the story.

The participants' initial attitudes and motives for joining the course

As discussed in Chapter 3, the perspective was taken that substantial shifts in the participants' attitudes would hardly take place if they did not come to the experience fairly willing to change. Other factors would be involved and come into play too, but this felt need for change was thought to be crucial. This sub-section starts, then, by exploring the participants' manifest and latent reasons for joining the Logo course. Following the analysis of the participants' motives for joining the course, three other issues are addressed: (1) the course participants' attitudes towards mathematics; (2) their attitudes towards the teaching of mathematics; and (3) their attitudes towards computers in the context of mathematics education. The analysis of each of these issues focuses on a few basic aspects identified as active driving and restraining forces underlying the participants' interactions with the course.

The participants' motives for joining the course

Note, first of all, that for many participants the decision to join the course was tied up more with the fact that the course involved the use of computers (and/or Logo) than linked with the idea that the course dealt with mathematics. Reflecting the incipient state of computer use in schools in Portugal, this tendency was stronger among the participants in this country than

among the participants in England. That is, for most of the Portuguese participants, the mathematics that the course had to offer played a distinctly secondary role. For the majority of the English participants, the relevance of the course was judged in terms of both the use of computers and/or Logo, and of mathematics.

The specific reasons given by the participants justifying their interest in learning about computers and/or mathematics were multiple. Most of the participants explicitly stated two or three motives. Other reasons were often revealed as a by-product of the participants' accounts of their attitudes. Still, in a few cases, further motives only became visible at a later stage in the course. Either these participants had latent motives which they had preferred consciously or unconsciously not to disclose during the pre-interview, or further motives were evolving or emerging as a consequence of the participants' involvement with the course. Such a web of reasons could be sorted into four broad categories: (1) *Personal agenda*; (2) *Practitioner*; (3) *Social influence*; and (4) *Commitment to change*.

The *Personal agenda* category is taken to include reasons such as: (a) professional career-related motives (e.g. Because I'm responsible for maths in the school); (b) the participants' self-growth (e.g. I'm interested in doing courses); or (c) a need for achievement (e.g. So that I don't feel left behind). These reasons were put together because they underline the fact that in stating such reasons these participants appeared to be more self-preoccupied than concerned with the application of the ideas that the course had to offer at classroom level.

The *Practitioner* motives are associated with reasons that emphasise the participants' increase of knowledge and skills to be used in the actual teaching situation (Lomax, 1987). These motives were far less frequently stated than the previous ones, but were still present in a considerable number of cases. The thinking underlying these kinds of reasons seemed to be: "I think that computers are important now in the classroom. ... I want to use them with my pupils. ...".

The *Social influence* category refers to the participants' decisions for joining the course that are made mainly as a reaction to initiatives taken by others. Motives in this category include reasons such as being asked/told to attend by the headteacher, having heard about the course from a friend, or other teachers in their schools were also attending the course. Often, these motives were inferred rather than explicitly stated as reasons to join the course. It was as if the participants preferred to invoke only motives that were personally founded.

Finally, there were a few participants who seemed to join the course *committed to change*. These participants' appeared to have been 'hurt' (Rudduck, 1988) because of their pupils' response to their mathematics teaching. The underlying thinking here seemed to be that the

computer (and Logo) had the potential to change the situation. As in the previous case, these motives were rarely claimed explicitly by the participants as reasons for joining the course. This kind of search (perhaps unconscious) for alternatives was echoed by one of the participants in the following way:

To be honest, I teach mathematics in a way that I don't like. Maybe I'm compelled to do so owing to constraints such as time, the curriculum..., but I think that I teach in a very structured way. I try to be less structured as possible, but I reckoned that it is still quite structured... Maybe the computer can make teaching not only of mathematics but also of other subjects more interesting... (Diana, P*)

Reasons tied up with the participants' professional careers were almost exclusive to the English participants. For instance, the English participants with subject responsibilities (mathematics and computing) in their schools appeared to hope to build on what the course had to offer to improve their expertise. As might be expected, such kind of reasons could not be found among the Portuguese participants (there are no teachers with subject matter responsibilities within the Portuguese primary schools). Also, *practitioner* motives tended to be more often expressed by the English participants than the Portuguese ones. It is possible that the Portuguese participants did not foresee that computers would be readily available in their classes in the near future. On the other hand, *need for achievement* motives were only expressed by participants in Portugal. A possible explanation for this is that the Portuguese participants thought that the computer, through its novelty value, could lead to a form of status differentiation between teachers.

The participants' initial attitudes towards mathematics

In depicting the participants' attitudes towards mathematics, two major categories are considered: (1) *Sensitivity to mathematics*; and (2) *Views of (school) mathematics*. *Sensitivity to mathematics* is an estimate of the degree to which the participants had adequate mathematical knowledge and had a favourable disposition towards mathematics, in order to be responsive to the mathematical stimuli provided by the course activities. Cognitive and affective variables are woven in the conviction that together they allow a better interpretation of the ways in which the participants dealt with mathematics throughout the course. Moreover, the concept of sensitivity takes into account both the objective and subjective aspects of the participants' experiences with mathematics over time. The second category refers to the teachers' views of both mathematics and school mathematics. The point was taken in Chapter 3 that teachers' views of mathematics were likely to be best explained by the idea that mathematics and school mathematics are separate spheres. As will be seen, this point is congruent with the findings of this sub-study, but, on balance, the teachers participating in it did not seem to be in a position to differentiate between the two spheres. Which is a better fit to "the reality" is an open question. Here the two are brought together.

* Here and in what follows P is the shorthand for Portugal, whereas E stands for England

Sensitivity to mathematics

The teachers participating in the Logo course hold the usual range of mathematical qualifications. In most cases, the participants had not pursued mathematics beyond the O-level or equivalent. In Portugal, a couple of participants (Clara and Emília) had the equivalent to A-level in mathematics. In England, one participant (John) had pursued mathematics at A-level, but did not obtain a pass. In addition, a couple of English participants (Katie and Debbie) had taken mathematics as one of their main subjects during their teacher training courses.

In line with the results of the first sub-study (in England, at least), there seemed to be a strong relationship between the participants' mathematical background and their feelings about the subject. The participants who were more likely to express feelings of enjoyment for and confidence with mathematics were those who had pursued mathematics to a higher level (A-level or post-secondary mathematics courses). Interestingly, this rule seemed not to be held true in Portugal. In fact, two Portuguese participants (Diana and Sara) appeared to have held strong mathematical self-concepts ever since they were in school, and yet they had not pursued mathematics beyond the equivalent of O-level (one of them, Diana, had not even obtained a pass in this examination). Bringing forward the discussion of these participants' interactions with the course, it became clear that they were not more competent in dealing with mathematics than their colleagues who had displayed more negative self-concepts. Clearly, being confident is not synonymous of being competent. Though the participants' subjective experiences with mathematics are important, they are obviously not enough to 'explain' the participants' attitudes towards the subject. The point is that both subjective and objective experiences are needed to make sense of the 'history' of the attitudes.

That the participants' subjective accounts in dealing with mathematics in the past are also fundamental was revealed, for example, when the participants themselves volunteered for talking about their feelings and experiences as pupils linking them with their contemporary attitudes. Here is an example:

I... on the whole I quite like it [mathematics], but I don't find it easy... I don't enjoy it in the same way that I would enjoy art or something like that, but... I mean, I think it's something that's very useful and I'm willing to learn, so I'm... fairly positive towards it... I don't feel that I've... I didn't feel that I was a particularly mathematical oriented person... when I was in school... I preferred other subjects, but at the same time I quite enjoy it... (Joseph, E)

Clearly, the participants build more upon their memories as pupils rather than their experiences at teacher training college. The fact is probably not surprising given that, in most cases, the participants' involvement with mathematics throughout their preparation as teachers was quite limited. In a few cases, the participants also indicate that their feelings towards mathematics have evolved as a result of their experiences as teachers. For example:

I now feel since I've been working with infants very, very positive about it. ... I'm much more interested than ever I was when I was a secondary teacher or I was a pupil in secondary school. ... I was very... I mean, I knew that I had to add up and I had to add and subtract and divide and I couldn't see much point in the geometry, I couldn't see much point to the algebra. [...] By and large my attitude was very negative because I was badly taught... (David, E)

It may be worth taking the analysis of these two participants' recollections of their feelings towards mathematics as pupils a step further, by looking at their attributions of those feelings. These appear to provide a tool around which to diagnose the extent to which the participants' feelings towards mathematics have evolved over time. In cases in which the participants attributed their feelings to external causes (e.g. being badly taught), these feelings may have been re-evaluated. For example, David came to move from feeling "very negative" to "very positive" about mathematics. When, as in the case of Joseph, the participants took personal responsibility for their feelings (e.g. not being mathematically oriented), then these feelings appeared to be more enduring.

A further diagnosis could be obtained by means of the participants' accounts of 'bad' and 'good' moments (Hoyles, 1980) in dealing with mathematics. Most participants were in a position to recall a 'particular' event which occurred just once within a particular situation. A few participants, however, found it difficult to select a 'particular' event, because either they always felt very comfortable in handling the subject or they generally felt bad while undertaking mathematical tasks. The participants in the latter group seem to have strong feelings about mathematics, and one may doubt that circumstances can emerge that would lead them to change those feelings.

Views of (school) mathematics

When in the pre-interview, the participants were asked to explain what mathematics is about, most of them had to think long and hard before they could give an answer to it. As expected, they found the question a difficult one. A couple of participants were even perplexed to realise that they had never thought about the question. In the words of one participant: "It's a question I never addressed to myself. And I could have done it. ... I've been teaching the subject for so long. ...". Without exception, however, probing meant that all the participants were able to express one or more beliefs (and disbeliefs) about mathematics.

To glean an impression of the participants' views, several initial interview comments concerning what mathematics is about are considered:

Mathematics is the Universe... If I had to tell a child what maths is about I would say that maths is life and rules the life... Maths is everywhere... And I would give examples to show them that they need maths... (Ana, P)

A very powerful language as it enables you to control and find out more about the environment. ... I think it's a language in its own right by its uses of symbol and notation. ... You can invent a piece of maths for the fun of it... (Katie, E)

It's playing games. It's puzzles, it's solving puzzles. In maths, you have to think and sort things out and give an answer which is either right or wrong... (Debbie, E)

Behind these comments were three somewhat distinct views. A first divide is into *unconscious* and *conscious* mathematics (Davis and Hersh, 1981). Some participants (e.g. Ana) appeared to carry with them the belief that the universe is governed by mathematical laws and that everything is mathematical. That is, mathematics is natural, it is unconscious. Other participants, like Katie and Debbie, seemed to place mathematics at a conscious level. The distinction between *analog* and *analytic* mathematics (Davis and Hersh, 1981) seems useful here. One relates mathematics to the real world and can be invented by almost everyone (*analog*), whereas the other stresses the mental processes and has implicit the fact mathematics is performed by very few people (*analytic*).

Now consider the following three comments:

It's a subject matter that deals with numbers and calculations... (Laura, P)

It's the science of numbers and of the relationships between numbers and how to apply them to solve problems. ... Maths is like a chain. ... The understanding of something leads to the understanding of another thing... (Clara, P)

It's a body of knowledge... It's a set of techniques to solve problems... to define certain things, as for example, everyday life things... Well, maths is more than that, high maths is more than that, but I'm not able to define... (Alice, P)

These comments illustrate a major aspect of teachers' conceptions of mathematics that had been postulated -- that of the distinction between mathematics and school mathematics. Some of the participants, as for example Laura, talked of mathematics in a way suggesting that their views were dominated by the mathematics of the primary school curriculum. Other participants seemed to think of mathematics as essentially a scientific discipline (e.g. Clara). Still other participants, like Alice, appeared to regard mathematics in different kinds of compartments that do not fit easily together: high mathematics, school mathematics and everyday life mathematics.

What is perhaps most significant in these comments is that they highlight that primary teachers can hold markedly different images of the meaning and substance of mathematics. The formation of these images, however, is not necessarily a self-conscious effort. Moreover, the image of mathematics may evolve and develop over time. Hence, in many cases within-subject comparison data from the pre-interview and the pre-questionnaire revealed apparently contradictory views. An example serves to illustrate this point, Katie, the participant who in the interview expressed the opinion that "you can invent a piece of maths for the fun of it ... ", answered the questionnaire items in a way that gave the impression that she held an *absolutist*

view of the subject. Her account of how she came to structure her views of mathematics as a result of her participation in a mathematics development project speaks for itself: "I think that the things that I've learnt myself through teaching maths, and through being in a maths team has done a lot to change my attitude... [...] Well, I won't say to change, but to develop further my attitude".

The participants' initial attitudes towards mathematics teaching

Three sets of related factors were considered of interest in examining the participants' attitudes towards mathematics teaching: (1) *Pedagogical mathematical expertise*, (2) *Aims of teaching mathematics*, and (3) *Pedagogy/teaching strategies*. The first factor is taken to include issues such as the length of primary teaching experience, the kinds of experiences the participants have had concerning mathematics teaching (e.g. programmes or courses attended, posts of responsibility), as well as their confidence in teaching the subject. The second category is the same attitudinal area considered in Chapter 3 and refers to what teachers consider to be most valuable in teaching mathematics, their intended purposes and outcomes. Finally, the category *Pedagogy/teaching strategies* refers to the conditions the participants normally created in their classrooms (*managerial* function) and the means they used (*instructional* function) to enable children to learn mathematics. It relates to the two attitudinal areas, *Nature of learning mathematics* and *The teaching milieu*, considered in Chapter 3. Again, I wish to suggest that these two attitudinal areas are distinct, but that they overlap and vary in imprecise ways. In fact, in considering the attitudes of the participants in the second sub-study in relation to these two attitudinal areas, one gets a sense of a *general* agreement between the two which is relevant to understand their actions during the course. The point is that the more specific one is in dealing with the different dimensions underlying the teachers' attitudes the less likely is one to find relationships between teachers' actions and those attitudes.

Pedagogical mathematical expertise

The course participants varied widely in their years of primary teaching experience (from little more than one year to over thirty-eight years), with the Portuguese participants constituting, as a whole, a group of more experienced teachers. Reading through the participants' comments during the pre-interview, one can note a striking contrast between more and less experienced teachers. Generally speaking, the most experienced participants seemed to be sure and proud of doing a good job. The least experienced participants, on the other hand, seemed to be less sure of their ability to teach. Lack of confidence could be reflected, for example, in the participants' relative unwillingness to disclose their views during the pre-interview. This was most evident in the case of a young participant in Portugal (Joana) who during the pre-interview limited herself to giving little more than monosyllabic answers.

Perhaps the most important emerging point was that in the middle of their professional careers, some teachers seem to experience some doubts about their ability to teach -- a kind of 'mid-life crisis'. It may be no accident that four of the five teachers who appeared to have been 'hurt' in their teaching of mathematics were teachers who had left the early years of teaching far behind. The suggestion is that these participants may have come to a stage in which they felt bored with their teaching and wished to do something different as part of their jobs. This suggestion is supported by the work of other authors. For example, Sikes (1985), in talking about the the life cycle of the teacher, states that:

It is during this phase that it becomes apparent whether or not the work of establishing occupational career, family and identity begun in the twenties and thirties has been successful; and it tends to involve self reappraisal, questioning what has made of one's life and searching for ways of expressing, fulfilling and satisfying oneself in the future. (p. 52)

This brings me to another important distinction that emerged during the pre-interviews: that between pedagogical expertise that was internally generated (based on the participants' experience in the classroom) and expertise which was externally generated (imported from other people's experiences and advice). At the time at which the pre-interviews took place, I was somewhat impressed by the accounts of some of the more experienced participants and the freshness of their ideas. In fact, this appeared to contradict the results of the first sub-study (at least in England), suggesting that more experienced teachers tend to hold more formal views about mathematics teaching than inexperienced ones. It was only in retrospect that I realised that these "informal" participants were exactly those who had participated in educational innovation (e.g. team teaching) and/or in long educational courses (e.g. Diploma in Education). The contradiction was in part apparent. Indeed, the findings of the survey had also pointed to an existing relationship between teachers' attitudes and their recent participation in in-service courses in mathematics education. What the interview data from the course participants highlighted is that this kind of relationship may be extended to include teachers' involvement in staff development programmes not necessarily related to mathematics education.

Another feature of the participants' pedagogical mathematical expertise seemed clear -- its relationship with their sensitivity to mathematics. To a great extent, the participants' confidence in their ability in teaching mathematics seemed to be largely determined by their feelings towards the subject. For example, one English participant (Joseph), who classified himself as non-mathematically oriented, was brave enough to admit: "I haven't had a very positive attitude towards teaching maths ... I lack confidence in teaching the subject ... I've neglected maths, I don't give it that much time ...". But it was possible to note some interesting exceptions to this general trend too. One instance was recorded, for instance, of an experienced Portuguese participant (Tânia) who, as soon as she switched from talking about her experiences with

mathematics as a pupil to her experiences as teacher, reversed the kinds of 'unfavourable' feelings she was expressing.

Aims of teaching mathematics

Perhaps more than in any other attitudinal area, the picture that one obtains of the participants' opinions about the aims of teaching mathematics is rather diffuse. Working from the participants' comments during the interviews and their answers to the questionnaire, one can easily conclude that most of them had multiple, and often inconsistent aims.

What might plausibly cause such kinds of ambivalence? A possible answer has been suggested by Miles (1981). In summarising the work of several authors, he notes that the goals of schools (and I will add those of teachers) are "inherently diffuse, vague, nontangible, and therefore hard to measure" (p. 61). He also notes that one of the reasons for these difficulties resides in the nature of the function of schools (and those of teachers): to bring about change in people and at the same time to transmit cultural and traditional values. Hence, while new goals are added, old goals are still maintained. I would like to offer a further explanation for the ambivalences noted in the participants' opinions about the aims of teaching mathematics -- one that is consistent with the hesitations and comments of some of the teachers participating in this study (e.g. the questions you asked led me to reflect...). In the same way that most of the participants seemed to have never thought about the nature of mathematics, they might also have rarely been encouraged to consider the reasons for teaching the subject.

Balanced with these cautions, it was possible to isolate some patterns, especially when one builds on the answers of each of the two groups of participants taken as a whole. First, in line with the results of the first sub-study, the Portuguese participants appeared to focus more upon the *individual-disciplinary* (developing thinking skills) and *scholarly-academic* (foundation for further mathematics) aims than the English ones. A second and more salient feature fleshing out the picture of the Portuguese participants is what may be called *goal displacement* (Miles, 1981). Indeed, while in answering the questionnaire the Portuguese participants rejected the *curriculum efficiency* aim, their accounts during the pre-interview clearly showed that their aims were isomorphic with those of the national curriculum and that much of their effort usually goes into having pupils to perform well in the tasks specified by it.

At the individual level, another interesting relationship emerged from the course participants' answers to the questionnaire items addressing the aims of teaching mathematics. The participants who had always found success and pleasure in their involvement with mathematics as pupils tended to consider as a priority the aim of having their pupils appreciate mathematics as well. Surprisingly, a similar commitment was expressed by most of the participants who

had had some traumatic experiences with mathematics as pupils. Their thinking seemed to be: "I don't want that my pupils have the same kind of bad experiences that I had". However compelling the commitment of the latter group of participants might be, the phenomenon is interesting in that it illustrates the lasting effects that experiences as pupils have upon teacher's attitudes.

Pedagogy/teaching strategies

From an *instructional* point of view, and bearing in mind the *transmission/constructivist* continuum (Cobb, 1988), it seems legitimate to assume that with one (or maybe two) exception(s) all the participants (both in England and in Portugal) fell near the end of the *transmission* paradigm. Basically, for these participants, school mathematics has a 'content' or 'things to learn' and rules to be followed, and the role of the teacher is to make sure that pupils learn these 'things' and know how to apply these rules. Nevertheless, in a way that was consistent with the results of the first sub-study, it was more likely to hear a Portuguese participant to speak of "acting as a role model" than an English one. In addition, in talking about their pupils' activities, the English participants were more likely to report that they spend some time in mathematical tasks of an open-ended or practical nature than the Portuguese ones.

As far as the *managerial* function of teachers is concerned, there was clear evidence of differences between the English and the Portuguese participants. Many of the emerging issues (e.g. classroom organisation, the role of children in learning, and the existence of resources and materials) have been treated elsewhere in this thesis. Here, I limit myself to the first of those issues, given its obvious connections with the use of computers in the classroom.

Grouping pupils according their ability was a must for most of the English participants. Accordingly, most of the time, children in these participants' classrooms tended to be seated in ability groups, each group working in different topics or even different subjects, and only occasionally, would pupils come together as a group. In the case of the Portuguese participants, one could note the three most common forms of arrangements (Cohen and Manion, 1981): the traditional one with children sitting in rows facing the blackboard, the modular arrangement with children sitting in groups, and the 'horseshoe' arrangement. But whatever the form of pupils' arrangements, the most common approach to mathematics teaching by the Portuguese participants seemed to be whole-class teaching, with all pupils engaged in the same kind of work.

The pedagogy /teaching strategies varied from participant to participant within the same country too. The nature of teachers' instructional methods seemed to be influenced by both the kinds of teaching experiences they have had and the contextual conditions in which they teach. For

example, the English participants who had had previous experience in the secondary sector tended, because of their experience, "to do a lot of class teaching as opposed to small group work". In turn, in Portugal, a participant teaching in a new open-plan school built during the period that followed the political revolution was involved in a team-teaching enterprise. (Note, however, that other participant from the same school had her classroom divided, and she and another colleague were teaching separately two different groups of pupils).

The participants' initial attitudes towards computers

This sub-section examines the participants' initial attitudes towards computers focusing on two categories: (1) *Readiness to use computers* -- the degree to which the participants possess sufficient experience with computers, and are willing to use them (sub-categories include computer knowledge and skills, commitment, and equipment); and (2) *Orientation to the use of computers in mathematics lessons* -- the participants' perceptions of the pedagogical approaches concerning the use of computers to support pupils' mathematical learning, as well as of possible advantages and disadvantages of using them in mathematics lessons.

Readiness to use computers

Not surprisingly, the contrast between the course participants in the two countries regarding their previous experience with computers was striking. In Portugal, only two participants had more than one year's experience with computers and had incorporated them into their teaching. A third participant had recently attended a 'computers in education' course. With the exception of these three teachers, the Portuguese participants had no (or very limited) experience with computers and they had no knowledge of Logo apart from possibly having heard of it. In England, all the participants reported that they had used computers previously, and many of them were familiar with educational software. Moreover, a couple of participants had had experience with programming with BASIC as well. As far as Logo was concerned, only one of the English participants appeared to be totally ignorant of what it was about.

Arguably, it is not possible to talk of participants' readiness to use computers without addressing the issue of availability of appropriate computer equipment. This became, in fact, a serious issue both in England and Portugal in considering the course participants' interactions with the Logo course. In England, all the participating teachers had access to computers in their schools. Real access to computers was, however, limited since the existing computers were to be shared by all the teachers in school according to a rota system. In Portugal, two of the teachers had already two computers in their classrooms, whereas two other teachers managed to get one computer for their classrooms during the course. The remaining teachers were also provided with one microcomputer each, but the complexities associated with the use of such computers posed considerable constraints to their utilisation.

Orientation to the use of computers in mathematics lessons

There was a major cross-country difference in the participants' opinions about the role of computers in mathematics lessons. Whereas in England the participants' opinions tended to be akin to their views about the role of computers in education in general, in Portugal, the participants' views about computers in mathematics tended to be drawn from their views about mathematics. This difference may be said to be associated with the substantial differences in the participants' experience with (and information about) computers in the two countries. Given the limited availability of and information about educational software in Portugal, the opinions of the participants in this country were most plausibly one-sided ones, influenced almost exclusively by their school mathematics perspectives. A further explanation resides in that in Portugal the existence of a national curriculum may impose on teachers the idea of subjects which are sharply "bounded and insulated" from one another (Bernstein, 1984, p. 200). In England, in contrast, the tendency in primary schools has been to look at the various subjects in an more "integrated" way.

Another contrast between the participants in the two countries was in the kind of concerns they expressed related to using the computer in their mathematics lessons. Once again, such a contrast may be associated with differences in their experience in using computers. The English participants tended to be primarily concerned with managerial and organisational aspects. The worries of the Portuguese participants were more likely to be related to the extra burdens that computers would impose on themselves (e.g. extra preparation time). One of the most interesting examples of a self-preoccupied participant is provided by one of the most experienced Portuguese teachers (Tânia). Throughout the pre-interview, Tânia was eager to talk extensively about varied issues concerning primary education. However, upon being questioned about the role of computers in mathematics, she just replied: "I have no idea". Given that all the other Portuguese participants gave a less elusive answer, I interpret such an answer as involving a certain degree of prejudice against computers (rather than simply a lack of opinion). Indeed, regarding herself as an expert teacher, Tânia probably feared not being able to excel with computers. Computers appear to represent something that could harm her self-image as a teacher and she was unable to commit herself to their use without admitting it openly (which would be equally disreputable). Some Portuguese participants also expressed concerns about the possible negative effects that the computers would have on pupils' mathematical learning. A few of them feared that children could regard the computer as a toy. Others were apprehensive about the fact that computers could encourage pupils' laziness. Still others were concerned with fitting the computer into an already overburdened timetable of keeping up with the prescribed curriculum.

In spite of these differences, it was possible to find three common patterns of opinions about the role of computers in mathematics lessons across the two countries. First of all, there was a view of the computer as a curriculum *supporter*, adding very little to the kind of mathematical experiences that pupils have in traditional classrooms (e.g. "To do calculations like in a worksheet ... To learn tables ..."). According to this view, the computer is just another tool, a product of the advance of science and technology, a *moderniser*, which is to be used because it is there. A second perspective corresponds to a view of the computer as a curriculum *modifier*. That is, the computer, and in particular its visual display, has the potential to modify how mathematics is presented, making it more attractive and enabling focusing on understanding. Within this view, the teacher attempts to capitalise on the computer to foster pupils' learning (e.g. "It's very good for them to learn... It's got the motivation... It's got the rewards, and it actually teaches new concepts..."). Finally, the third view suggests a perspective of the computer as a *change agent* with its potential to change dramatically the kind of teaching/learning that takes place in schools. From this view, pupils would have the opportunity to do mathematics rather than just focusing upon the mathematics of the curriculum (e.g. "A tool to explore aspects of maths and to question and to find out...").

Factors that affected the participants' interactions with the Logo course

There were, clearly, innumerable reasons why an individual participant interacted with the course as he/she did, and changed or did not change his/her attitudes throughout his/her involvement with it. In this section, an attempt is made to bring together the data generated across the seventeen participants in order to assemble in one place the patterns of the participants' interactions and the most important factors that seemed to account for these interactions.

I identified eight major factors. Six of these factors, all discussed in the previous section, concern the participants' initial attitudes and motives for entering the course:

- *Motives for joining the course*
- *Readiness to use computers*
- *Sensitivity to mathematics*
- *Views of (school) mathematics*
- *Pedagogical mathematical expertise*
- *Pedagogy/teaching strategies*

Another factor that emerges from the adult learning literature concerns the participants' *learning orientation*. This centres around the course participants' preferred way of learning. I use this

expression in the same sense as Korthagen (1988), to refer to the extent to which the participants preferred to learn through an external direction (*conformist* orientation) as opposed to learning through self-direction (*autonomous* orientation). In considering this variable, a distinction must be recognised between the participants' own orientation to learning and their views of pupils' learning. In fact, it became apparent that the participants could well espouse/express views akin to an *autonomous* orientation to learning in relation to their pupils and prefer a *conformist* orientation concerning their own learning.

Thus far, I have been concerned only with factors that seemed to have influenced the participants' interactions with the course essentially at the individual level. Attention is now turned to a set of features that appeared to have affected their responses to the course at the group level: *course climate* (e.g. working arrangements, scheduling, equipment) and *cultural norms* (e.g. risk taking, tolerance of diversity, cooperativeness, socialisation, power structure). While the influence of such factors are not the main focus of this study, they cannot be ignored either, as they seemed to have played a key role in the participants' reactions to the course.

The remainder of this section is organised around each of the eight factors identified. The discussion centres on how each of these factors impinged on the participants' responses to the course in terms of how they achieved (or did not achieve) the course aims, namely those of: (1) developing personal competence with the computer and Logo; (2) using Logo for doing mathematics; (3) developing confidence and enthusiasm to use Logo in the classroom; and (4) reflecting upon pedagogical issues related to the teaching of mathematics. By way of anticipating the discussion that follows, Table 6.2 gives a thumb-nail sketch of what factors are associated with each of those four aims.

Table 6.2: Relationships between the participants' achievement of the course objectives and eight identified factors

Factors	Objective 1: <i>Competence with Logo</i>	Objective 2: <i>Linking Logo with maths</i>	Objective 3: <i>Use of Logo in the class</i>	Objective 4 <i>Reflection upon pedagogical issues</i>
<i>Motives for joining the course</i>	X	X	X	
<i>Readiness to use computers</i>	X	X	X	
<i>Sensitivity to mathematics</i>		X		
<i>Views of (school) mathematics</i>		X		
<i>Pedagogical mathematical expertise</i>			X	X
<i>Pedagogy/Teaching strategies</i>			X	
<i>Learning orientation</i>	X			X
<i>Course climate and cultural norms</i>	X		X	

X = relationship noted unambiguously in most of the cases; Blank = no unambiguous relationship noted

Motives for joining the course

Perhaps the most important and basic factor for understanding the unfolding of the participants' interactions with the course is their motives for joining the course. It seems to account for: (1) the extent to which the participants put considerable energy in building competence with the computer and Logo (at least in the earlier stages of the course); (2) the extent to which they engaged in mathematical activity throughout the course; and (3) the kind of conditions the participants created to implement Logo in their classrooms and how these conditions were sustained.

Generally speaking, it seems that the participants who were *committed to change* and/or had *personal agenda* motives in mind were more enthusiastic and committed to making efforts to increase their competence with the computer and Logo than those who indicated *practitioner* motives or those who were joining the course mainly as a reaction to initiatives taken by others. Throughout the course sessions, the participants in the former two categories would initiate the Logo activities quickly, their involvement with these activities was high, and in most cases they would be able to complete them successfully. Moreover, it was not rare for them to extend their Logo work between the sessions and/or to come earlier to the sessions to try new ideas or redo the work they had done at home. They also seemed less anxious and vulnerable in coping with the difficulties and problems in using the computer and Logo than the participants in the other groups.

To get a flavour of the different kind of feelings experienced by the participants with distinct motives for joining the course, here are the reactions of two Portuguese teachers at the end of the first session. One of them (Tânia) talked of being confused and "being thrown into the water without knowing how to swim", having considered the casual tone of my intervention as a course tutor during the session as a sign of disorganisation. The other participant (Ana) who had joined the course with a *need for achievement* rationale in mind commented: "I enjoyed the shock treatment... Probably, I wouldn't cope better with the computer if a more structured approach had been used...".

However, not all the initially highly motivated participants remained committed to learning and using Logo, and were able to develop competence with the programming language. For one reason or another, some participants did not get the enabling conditions which would allow them to succeed and came to be lukewarm about their involvement with the course if not detached from the experience. The reverse is also true. That is, some of the participants who appeared to be initially lukewarm or wary about joining the course, came to feel committed to learning and using Logo as the course progressed, and were able to build considerable competence with it.

Level of commitment to use Logo in the classroom appeared also to be strongly related to the participants' motives for joining the course. In particular, *need for achievement* motives seemed to play a crucial role in supporting the implementation in the classroom process. These kinds of motives might have contributed to the striking differences in the levels of enthusiasm and commitment to the course requirement to implement Logo in the classroom shown by the participants in the two countries. Indeed, while 'need for achievement' motives were only explicitly referred to by a couple of participants in Portugal, it is possible that a similar reason existed among other participants in this country as well. That is, using the computer in the classroom might have been regarded foremost as a change in the professional self-image of most Portuguese participants, and a motive for respect from pupils, and probably from peers and parents.

As a corollary to this, the majority of the Portuguese participants appeared to be more keen to accept my visits to their classrooms to introduce the Floor Turtle, and put more creativity into devising learning environments for the use of Logo with their pupils during these visits than the English participants. For example, one of the English participants (Paul) was unable to make arrangements so that I could visit his classroom. Still another English participant (Mark) agreed with my visit, but when I arrived in his school he had taken part of his class on an outside trip. For most of the Portuguese participants, in contrast, my visit to their classrooms took on the shape of a major event having priority over other classroom activities and mobilizing the enthusiasm of both participants and their pupils, as well as the participation of other teachers in their schools.

Interestingly, the participants with career motives in mind did not appear to be greatly committed to implementing Logo with their pupils. It was as if they were above all taking advantage of opportunities crossing their paths. They might have felt personally committed to developing competence and confidence in using the computer and Logo, but they were probably assessing first of all the implications of their use in the classroom and therefore waiting for another opportunity to make changes at an instructional level. The same may be said of the participants who joined the course with *practitioner* motives in mind. Finally, the participants who joined the course especially as a result of social influence were perhaps among the least interested in implementing Logo with their pupils. Naturally, they could not find sufficient justification for the effort and disruption that it would bring to them.

Finally, as might be expected, the extent to which the participants' engaged in mathematical activity and perceived their Logo work as mathematical seemed to covary with the focus of their interest in joining the course -- mathematics or computers (and/or Logo). The point here is that the participants' initial expectations about the mathematics the course had to offer defined

the situational goals towards which their actions and thoughts were directed. This pattern of relationship is better illustrated from a cross-country perspective. In Portugal, only one or two participants referred to mathematics when they were asked the motives for joining the course in the pre-interview. Thus, for most of the Portuguese participants, the emphasis on the mathematical features of the course was limited and their perceptions of the mathematics in which they were involved restricted to a couple of ideas related to estimation and angles. In England, all but one of the five participants initially interested in the mathematics that the course had to offer came to show considerable involvement with it.

Readiness to use computers

Readiness to use computers appears to be another important factor influencing the participants' interactions with the course. It appeared to be associated with three of the course objectives: (1) development of competence in using the computer and Logo; (2) commitment to using Logo with their pupils; and (3) engagement in mathematical activity.

In analysing the dribble files of the participants' work during the earlier sessions, one finds notable differences between computer-experienced and computer-novice teachers. For example, the computer-novice participants had to resolve relatively trivial issues related to the use of the computer keyboard, such as not lifting a key after pressing it and forgetting to press the SPACE key. Moreover, the computer-experienced participants were able to blend the information provided in the handouts with their existing schemata of how to operate a computer to guide their behaviour. Experimenting, seeing the results of their own actions, and trying again if necessary seemed to be processes which they were already accustomed to.

Differences related to the issue of the participants' readiness to use computers were particularly clear in comparing the interactions with Logo of the Portuguese and the English participants. For example, during the first session, the English participants were able to make sense of the basic primitives of Logo more quickly than the Portuguese teachers and moved on to learn more complex features of the language (e.g. the REPEAT command, how to define a procedure). Moreover, by the seventh session, most of the English participants were familiar with the use of procedures with variables and were able to use recursion, whereas most of the Portuguese participants did not ever become familiar with this idea at all.

Readiness to use computers is not an event, but an accomplishment. Thus, over time, a few of the less experienced participants (e.g. Joseph, E, and Clara, P) demonstrated remarkable ability to deal with the mechanics and skills of dealing with the hardware, the keyboard, and the programming language. On the other hand, it was also evident that not all experienced

participants who had an easy initial phase came to increase their confidence and competence with the computer and Logo (see, for example, the case of Diana presented later in the chapter).

Associated with the participants' degree of preparation to use the computer and facilitating or hindering their building of personal competence with Logo was the presence or absence of appropriate computer equipment in their schools. The participants who had access to computers in their schools could extend their work with Logo, thus increasing their personal competence as well. In some cases, this kind of relationship was very close. For example, three of the course participants, John and Joseph (in England), and Alice (in Portugal), who at the end of the course displayed considerable competence with the computer and Logo, had appropriate resources in their schools. Sometimes, however, there was no relation at all. For example, Rosa (in Portugal) had a computer available in her classroom and still she developed little competence in using the computer and Logo. (Obviously development of personal competence with Logo depended on other factors such as, for instance, their own orientation to learning.)

The participants' readiness to use computers, including availability of appropriate computer equipment in their schools, also appeared to influence the extent to which they were committed to the course requirement to use Logo with their pupils. For example, unfamiliarity with hardware and complexity in running Logo appeared to have substantially reduced some of the participants' initial commitment to that requirement. Availability of computers in the participants' schools, however, was not a determining factor. In line with the findings of other researchers (e.g. Joyce and Showers, 1984; Hoyles, Noss and Sutherland, 1991), data from this study suggest that appropriate support and assistance in the classroom were essential ingredients to lead the participants to incorporate the ideas generated in the course. Receiving assistance and feeling supported, in fact, appeared to help in lowering the participants' anxiety (especially in the case of novice computer users) in trying new ideas, and increasing their commitment.

The degree of preparedness to use computers (and how it evolved as the course progressed) seemed also to be associated with the extent to which the participants engaged in mathematical activity. For example, at the initial stage of the course, the computer inexperienced participants seemed to be overwhelmed with the complexity of learning how to use the computer and the Logo language features, and therefore pay little attention to the simple mathematical ideas involved in making the turtle draw.

A similar phenomenon could be noted at a later stage of the course among the English participants. Those English participants who had engaged in mathematical investigations, emphasising hypothesis making and generalisations, were those who had developed a higher

level of competence with Logo. In other words, expectations for creative, open-ended, exploratory mathematical activities are unlikely to be met if the participants could not use Logo features such as procedures with variables and recursion.

Sensitivity to mathematics

The participants' sensitivity to mathematics appeared to have affected to a great extent their ability to engage in mathematical activity and, in particular, in programming with Logo. The participants who had taken mathematics at A-level or equivalent, or at the post-secondary level felt relatively at ease in conceptualising some aspects of programming which are thoroughly mathematical (e.g. procedures with variables, control structures). In contrast, most of the participants who had a lower mathematical background had substantial difficulties not only in coping with Logo programming features, but also in solving relatively simple problems of a mathematical nature (e.g. undoing a drawn arc).

The participants' ability to engage in mathematics similarly arose at another level of participants' sensitivity to mathematics -- that of affective nature. Throughout the course sessions, the participants with higher background in mathematics became increasingly involved in their mathematical problems and displayed excitement at getting things done. On the other hand, the difficulties faced by some of the participants with lower mathematical background were often compounded with feelings of anxiety and embarrassment. This was especially so in cases in which the participants had had some kind of traumatic experiences with mathematics when they were at school. The image is one of returning to old feelings of helplessness in dealing with the subject. That is, feelings such as "having a block about maths" experienced by the participants in the past as pupils seemed to interfere with their current learning experience with Logo.

The importance of examining the two sides of the coin, the cognitive and the affective, became clearer in considering the cases of two Portuguese participants (Diana and Sara). These two participants hold a very positive self-concept about their ability to deal with mathematics, but they had not pursued mathematics beyond O-level. Interestingly, what emerges from the analysis of these participants' interactions with the course is that the influence of such positive images on their ability to engage in mathematical activity was negligible. Their lack of mathematical knowledge constrained what they could do, and what they did was similar to what other participants with lower self-concepts did.

The question arises as to whether the mathematical Logo-based environment provided by the course contributed to changing the participants' ability to engage in mathematical activity. As the course progressed, it became increasingly apparent that the course was having some *effects*

on two different groups of participants. First, for the participants who regarded themselves as *arts oriented*, the computer and Logo appeared to have represented the dawning of an interest in doing mathematics and feeling excited about it. The graphics aspect of Logo seemed to have appealed to these participants and encouraged them to take an interest in exploring visual effects with it. Concomitantly, they appeared to have developed an awareness that they were involved in engaging in mathematical activity. The kind of freedom that these participants experienced with the computer and Logo seemed to suit their *artistic* tendencies well. The interactions of these participants with Logo appear to support Papert's (1980) contention, stressing the importance of aesthetic factors in people's mathematical thinking and activity: "mathematical thinking and activity have at least as much claim to be called aesthetic as logical" (p. 197).

Another group of participants whose involvement with mathematics was *transformed* by their experience with the Logo course was that of the participants with a relatively high background in mathematics (A-level or equivalent, or post-secondary mathematics). From an *everything planned before engaging in Logo programming activity* approach, they came as the course progressed to use a more *exploratory* one. These participants could enrich their experience by combining their initial plans and goals with exploration and inquiry -- by varying them, by seeing what else happens or 'what happens if?'. They would pursue their activities until they reached the set goals, but at the same time they would come up with related activities of a more open-ended nature.

Views of (school) mathematics

It has been noted that the participants had invested little time in reflecting upon what mathematics is about, and that the opinions expressed were more the result of a short-term thought than the product of a lasting self-conscious effort. Under these circumstances, it is not surprising to find that the relationship between the participants' interactions with the course and their expressed views of mathematics/school mathematics is a weak one.

Now, it may be instructive to look more closely at this important issue and shift attention from the participants' expressed views to the mathematics/school mathematics that they have been exposed to. It seems legitimate to conclude that these considerably affected the mathematics that they were doing during the course. Indeed, clear differences could be noted between the English and the Portuguese participants in the kinds of mathematics that they were using and sorts of mathematical activities that they were engaged in. For example, during the early sessions, the English participants tended to be more accurate in their estimations of lengths and angles than the Portuguese ones. Also, the participants in England extensively used decimal numbers for inputs of the primitives to move the turtle, whereas in Portugal only a couple of teachers did so occasionally. An even greater discrepancy was noted in the pattern recognition

capabilities of the two groups of participants. The Portuguese participants did not seem to be as good as the English ones in recognising patterns, or at least were less likely to make use of such patterns to solve a problem.

Another difference between the Portuguese and English participants was related to the use of higher-order strategies to solve a problem. This was, for example, evident in the participants' approaches to solve the "Playing with Words" task (see Chapter 4 for details about this task). The English participants seemed more likely than the Portuguese participants to realise that the problem could be solved by decomposing it into sub-problems. The "Playing with Words" task can also be used to illustrate that the Portuguese participants and the English ones differed in the ways in which cognition is involved in the affective response. Recall that the task included, as a nudge to introduce the idea of Logo procedures, the question of how from a suggested word another word with the same letters could be obtained (e.g. Can you make TOLA from ALTO?). Rather than drawing the first word (e.g. TOLA) and eventually think of a solution to draw the second word, some of the Portuguese participants (e.g. Alice and Clara, Diana and Emília) opted for drawing straight away the second word. Moreover, one of the pairs (Diana and Emília) decided to replace the *outline* format of the letters (e.g. T) by the *plain* one (e.g. T). These responses to the task may reflect the participants' belief that mathematical problems should be solved as quick as possible.

Another important difference was noted at a later stage in the course, in the ways the English participants and the Portuguese participants responded to the suggested Logo-mathematical investigative activities (e.g. Investigating Stars, Investigating Spirolaterals). For most of the English participants, these activities seemed quite natural. The Portuguese participants showed little familiarity with this kind of task as I expected they would show, and scarcely recognised them as mathematical activities. Nevertheless, some of the Portuguese participants (e.g. Ana, Alice) did become motivated to engage in such kind of activities and showed some enthusiasm in so doing.

My interpretation of these data is that they replicate the finding of the first sub-study suggesting that there are considerable differences between Portuguese and English primary teachers in their views of mathematics/school mathematics.

Pedagogical mathematical expertise

Overall, the participants' pedagogical mathematical expertise seemed to account for: (1) their commitment to using Logo in the classroom; and (2) their ability to reflect upon pedagogical issues.

The effect of the participants' pedagogical mathematical expertise in their commitment to using Logo in the classroom appears to be very clear. The participants with less experience as primary teachers seemed to be less committed to investing time and energy in implementing Logo in the classroom than the participants with greater teaching experience were. The inexperienced teachers have a less adequate, or at least less complete, pedagogical expertise, and therefore felt less at ease trying something new in their classes. At the beginning of their careers, teachers might be especially concerned with the usual demands of teaching to be burdened with extra activities. It may be worth considering here the case of an young English participant (Joseph) who throughout the course sessions developed a considerable personal expertise with the computer and Logo. Although he reckoned that his attitude towards computers "improved very dramatically" and that Logo was exciting, he never felt ready to invest time and effort to use it in the classroom with his pupils. The case of an English participant (David) at the very beginning of his career as primary teacher who initially seemed to be greatly motivated to use Logo in the classroom is also illustrative. In spite of his initial motivation, this participant came to show little commitment to do so during the course. His answer to the question about what stood for him in the course is illuminating: "I found the video very useful ... watching that tension ...". Obviously, he was not ready to act as a fully committed professional, and preferred to be shown what to do.

On the other hand, the experienced participants appeared to have appreciated the challenge of bringing some refreshment to their usual practices. Innovation might have been regarded by them as a way of moving from the boredom of doing the same thing all the time. Thus, differences in teaching experience might have accounted for the differences found between the participants in the two countries concerning the use of Logo in the classroom. That is, given that the Portuguese participants constituted a group of more experienced teachers than the English ones, they might have felt more comfortable in trying something new in their classrooms.

The relationship, however, is not a linear one. Some of the most experienced participants behaved in ways that resembled the inexperienced ones. They seemed to be worried about the fact that in using the computer in their classroom they would be in an unusual situation. The prospect of not being more in control of the knowledge they needed to perform well in class than were their pupils appeared to constitute a threat for them. This kind of fear was clearly expressed in the pre-interview by one of the most experienced Portuguese participants (Tânia): "I'm not going to place myself in front of my pupils as ignorant as themselves in working with the machine".

Differences in the participants' pedagogical expertise also seemed to account for the extent to which they engaged in reflection upon pedagogical issues. In fact, if one takes Kemmis' (1987) point that "to reflect critically is to locate oneself in an action frame, to locate oneself in the history of a situation, to participate in a social activity, and to take sides on issues" (p. 75), then reflection and pedagogical expertise are closely related. The point is that the sense of empowerment and confidence associated with considerable experience in teaching primary school children encouraged most of the experienced teachers to be responsive to the course activities that aimed at fostering reflection upon pedagogical issues, such as group discussions and the development of the Logo group project. In contrast, the inexperienced participants appeared to be looking for help, direction and suggestions to try in their classroom rather than being expected to put forward their own ideas.

Pedagogy/teaching strategies

While not a determining element, the participants' pedagogy/teaching strategies appeared to be a highly influential factor in terms of what they did or did not do in using Logo in the classroom. For example, an examination of the participants' working arrangements to introduce the Floor Turtle seemed to reflect, in general, the approaches that they would normally follow in their classrooms. If they were accustomed to having pupils working in groups, then they would organise a similar group work pattern in operating with the Floor Turtle. In a similar vein, when whole-class teaching was the usual working framework, participants would make use of this very framework.

In addition, in agreement with my previous observations about the participants' pedagogy/teaching strategies in England and Portugal, a major difference was found between the two groups of teachers in the ways in which they organised the Floor Turtle work. Irrespective of the organisation of their classrooms, the Portuguese participants clearly wanted all their pupils to have the same kind of experiences with the Floor Turtle. Thus, even in the cases where small group work had been organised, they made sure that enough time was provided for each group to have a go with the computer and the Floor Turtle. In contrast, most of the English participants had selected one or at most two groups of pupils to work with the Floor Turtle. (Interestingly, the only exception to this was provided by the participant, David, who during the pre-interview had indicated that, as a result of his experience as a secondary teacher, he tended to use whole-class teaching as opposed to small group work.)

Furthermore, in terms of teacher-pupil relationships, the picture provided by most of the participants was one of teacher-directed instruction on tasks set by themselves. In general, the teacher would ask closed questions, trying to elicit pupils' knowledge but making little use of children's informal experiences. Then, he/she would wait a little for the pupils to give the

answers, thus suggesting a focus on getting the task finished rather on the processes of getting the task done.

This is not to say that circumstances in which the Logo work took place were the usual ones in all aspects. Other factors interfered with the participants' pedagogy/teaching strategies. For example, reasons were present that made most of the Portuguese participants respond to the trial with exceptional efforts. The introduction of the Floor Turtle entailed the organisation of learning environments that appeared to involve a less formal atmosphere and a greater emphasis on cross-curricular links than that would be usual in a traditional mathematics lessons. An exception provided by a couple of Portuguese participants confirms the rule. These two participants (Tânia and Rosa), members of staff of the same school, avoided submitting their pedagogy/teaching strategies to my scrutiny by leaving the task of creating a learning environment for introducing the Floor Turtle to their pupils to myself.

Also, for the participants who were (or became) committed to using the computer and Logo with their pupils and ventured to do so during an extended period, this experience appeared to have provided them with the opportunity, if not the need, to develop alternative teaching strategies. The most obvious shift that I noted when I visited these participants' classrooms the second time was in teacher-pupil relationships. Indeed, there was a tendency to use a less structured way of relating to the pupils, at least in relation to the pupils working with the computer, encouraging their autonomy and self-direction.

Learning orientation

The participants' own orientation to learning appeared to have greatly influenced what they did and did not do in terms of: (1) building their competence with Logo; and (2) the extent to which they were able to reflect upon pedagogical issues.

In both countries, most of the participants appeared to have approached the Logo course with a preconception that this would follow the conventional didactic model of instruction. Whether they came to accept the course emphasis on self-direction and make a transition from a passive role in learning to that of assuming responsibility for their own learning seems to be related to individual characteristics and experience. Thus, in both countries, there were participants who appeared to have derived satisfaction from the course approach and learned to challenge themselves, as well as participants who never felt comfortable with the self-directed approach to learning and for whom the course became a source of frustration and disappointment. All other factors being equal (or at least more or less the same), when a participant had a *conformist* orientation to learning, he/she would scarcely make any progress in building confidence with the computer and Logo. In contrast, an *autonomous* orientation to learning

seemed to be a catalyst for personal growth. Two good contrasting examples are the cases of Diana and Alice which are presented at the end of this chapter.

The participants' *learning orientation* also appeared to be associated with their ability to reflect upon pedagogical issues. It seems obvious that from Kemmis' (1987) perspective, reflection was most unlikely to occur if a participant had a *conformist* orientation to learning. In fact, the participants with a *conformist* orientation to learning tended to prefer to be directed and follow other people's ideas, as well as avoided choosing among alternatives. In contrast, participants with such attitudes as openness, confidence and initiative tended to inform and be influenced by others. These are thought to be essential ingredients for engaging in reflection. I would like to suggest that the same kind of relationship happened with a more private form of reflection -- that which takes place when one "looks back at the teaching and learning that has occurred and reconstructs the events, the emotions, and the accomplishments" (Wilson, Schulman and Richert, 1987, p. 120).

The examples of the English participants, Katie (*autonomous* orientation) and Mark (*conformist* orientation), serve to illustrate the contrast. Katie had a vast repertoire of teaching strategies, routines, and theories and was eager to share them with the remaining participants. In many instances, she would stand in opposition to other participants' opinions and even to my suggestions. Her comments during the post-interview indicate that throughout the course she often reflected upon her own role as a Logo learner, as well as upon her pupils' learning in working with Logo (e.g. I think I didn't give them enough time to explore things for themselves). Mark represented the opposite extreme of the continuum. For example, his involvement with the development of the Logo group project was minimal. During the group discussions, he rarely expressed his ideas. This participant's reactions to the course suggest that the kind of environment he found in the course offered little to stimulate him to reflect upon pedagogical issues. His comments in the post-interview when asked whether he had reflected on the role of teacher and pupils in a classroom situation, he responded: "No, not really... I don't think so... It's a different situation...". On second thoughts, he added: "Oh... yes, I could see the links to being on the course...", but it was clear that it was the first time that he had thought about the issue.

Course climate and cultural norms

The influence of these factors appeared to be rather visible in: (1) the extent to which the participants developed confidence and competence in using the computer and Logo; and (2) in their commitment to and enthusiasm for using Logo in the classroom.

Just as important to learning as individual characteristics and attitudes is the set-up of the learning environment. Attempts were made so that the settings of the courses in Portugal and in England were as similar as possible. Unfortunately, the different structural conditions existing in the two countries meant that the created settings were considerably different. In England, the course was held in a well-equipped computer laboratory of the Institute of Education University of London. In Portugal, the course took place on the premises of a secondary school (one of the schools involved in the MINERVA project). Two rooms were used for the course. A small room which had recently been transformed into a computer lab and a bigger room (an annexe to the first one) which was used for off-computer activities and group discussions. The dimensions of the computer room (and the limited number of computers available in Portugal) along with the number of Portuguese participants in this country, meant that in some instances the whole group had to be split. This was so either to allow for individual work with the computer or in order that in a group discussion all the participants had the opportunity to talk. One of the effects of this was that my absence from the computer room to interact with the participants in one of the sub-groups would lead to decreasing my assistance to the participants in the other sub-group, and this possibly reduced these latter participants' involvement with the course activities.

Also, existing cultural norms (e.g. risk taking, tolerance of diversity, collaborativeness, socialisation) seemed to have affected to a great degree the participants' individual growth with the computer and Logo. For example, a spirit of collaboration seemed to be present among most of the English participants. In fact, these participants would engage in relatively frequent exchange of task-related information. They also seemed to derive satisfaction from creating something and having their peers enjoy, understand and appreciate what they had done. At the final interview, many of the English participants stated that the exchange of views and sharing of ideas and methods with other participants was of great value. The following comment by a course participant in England (Joseph) serves as an illustration:

I thought it was nice when we looked at what other people were doing, not just at the end but other times during the course. We've had a chance to see what other people were doing and I found it interesting to see the approach that other people had ... and also to be able to swap ideas with the other people, I find that quite useful. I think that was that particularly stood out for me ... the fact that we were learning together...

In Portugal, in contrast, it appeared that the participants were conditioned by norms of a traditional classroom structure in which emphasis is placed upon competition and individualism. At the final interview, many of the Portuguese participants commented on feelings of anxiety and disappointment during the earlier stages of the course, due to the fact that they were not doing as well as their more computer-experienced fellows. Lack of a stimulating *esprit de corps* was also evident during the participants' development of the Logo

group project. For example, one of the Portuguese participants (Ana) expressed her concerns about her involvement with this activity as follows:

When I'm working alone I'm able to do the things ... but with a group I'm not ... I'm a very individualistic kind of person, well not a bad sense anyway ... But since I spend all my professional life, more than 32 years, working alone ... when I work within a group I've got a kind of mental block, and my contribution to the group is very little.

The cooperative stance taken by most of the English participants seemed to have promoted greater success in solving the Logo activities and increase their motivation to persist in striving to accomplish set goals than in the case of the Portuguese participants.

Interestingly, while the English participants appeared to engage in more cooperative computer and Logo work than their counterparts in Portugal, they seemed less interested in off-task socialising. Indeed, the time planned for coffee-breaks was never taken as an opportunity for the English participants to come together and interact in a non-learning oriented way. It was as if the English participants were more interested in maximising the time for interaction with the computer than in socialising. In contrast, most of the Portuguese participants welcomed the coffee-time break and appreciated the opportunity to socialise. The tendency to be sociable seems to be greater among the Portuguese teachers than the English ones. Such trend, which may be said associated with the different levels of development of England and Portugal, could also be noted when I visited several primary schools in the two countries as part of the present research.

The participants' commitment to the course requirement to use Logo in their classrooms also appeared to be influenced by cultural norms, namely compliance to authority. In fact, the Portuguese participants might have felt constrained by the fact that the course was endorsed by the MINERVA project (the governmental project to implement computers in schools in Portugal). In other words, the commitment of Portuguese participants to using Logo in the classroom may be regarded as either a form of compliance to a perceived power structure or as a wise thing to do in terms of the hope of future support by the MINERVA project.

What might have operated, too, in heightening the Portuguese participants' enthusiasm in using Logo in the classroom was a competitive tension among themselves, the same kind of competitive tension that could be felt with regard to their own development of competence with the computer and Logo. Undoubtedly, there was a desire among most of the Portuguese participants to perform at a satisfactory level during my visit to introduce the Floor Turtle. And, in fact, they succeeded in doing so to the extent that I was considerably impressed by their work. This was in striking contrast with what happened in England. For most of the English

participants, my visit to their classrooms to introduce the Floor Turtle constituted only a small part of their daily activities, and they got by with the minimum of extra work possible.

The fact that the course provided the participants with ideas and frames of reference which were embedded in a strong English flavour (such as as the video film *Turning Point*) might also have had important implications for the Portuguese participants' self-esteem and their own feelings of identity. They clearly wanted to be regarded as 'good' professionals as their colleagues in England. Hence, a desire to excel in order to keep a favourable reputation. This kind of concern was upheld by one Portuguese participant (Clara) at the end of the post-interview. (It may be instructive to recall that this participant was the teacher who has involved in the training of primary student-teachers.) When was asked for any further comments, she remarked:

Well ... I've already said so many things. Maybe ... I would like to see whether the teachers in England are more experienced than us, what they do differently. I would like to know, because many people say that we Portuguese people are behind other countries, and I don't agree with that and I'm not pleased with that ... [...] Normally, we are accused of teaching ... that their teaching is more pedagogic, more correct, with better results ... We've always been trying experiences that are already out of fashion. ... [...] I would like to see my 7-8 year-old-pupils, how they would do within mathematics compared with children of the same age in England. ...

Towards a causal model of teachers' interactions with the Logo course

Having discussed how each of the eight factors were associated with the course aims, I would like to propose a causal model that attempts an integrated explanation. Figure 6.1 displays this model in a schematic format to show the eight predictors and the four course aims considered, and the nature of their interrelationships.

To read through the schema, I will start with the factors that influenced the participants' development of confidence and competence with the computer and Logo. These include the participants' *motives for joining the course*, their *readiness to use computers*, as well as their own *learning orientation*. These three factors essentially refer to characteristics of the individual participants. In addition, personal growth with the computer and Logo was also affected by factors that worked at the group level, namely the *course climate and cultural norms*.

Moving to the next course aim, the extent to which the participants were using and doing mathematics while engaged in Logo activity seemed to be influenced by four major factors. Two of these factors are unique to this particular aim. They are related to the participants' attitudes to and previous experiences with mathematics: *sensitivity to mathematics* and *views of (school) mathematics*. An added set of causal factors was also in play. These are more general factors, ones which seemed important to several course aims, including the one examined above: *motives for joining the course*, and *readiness to use computers*. On the other

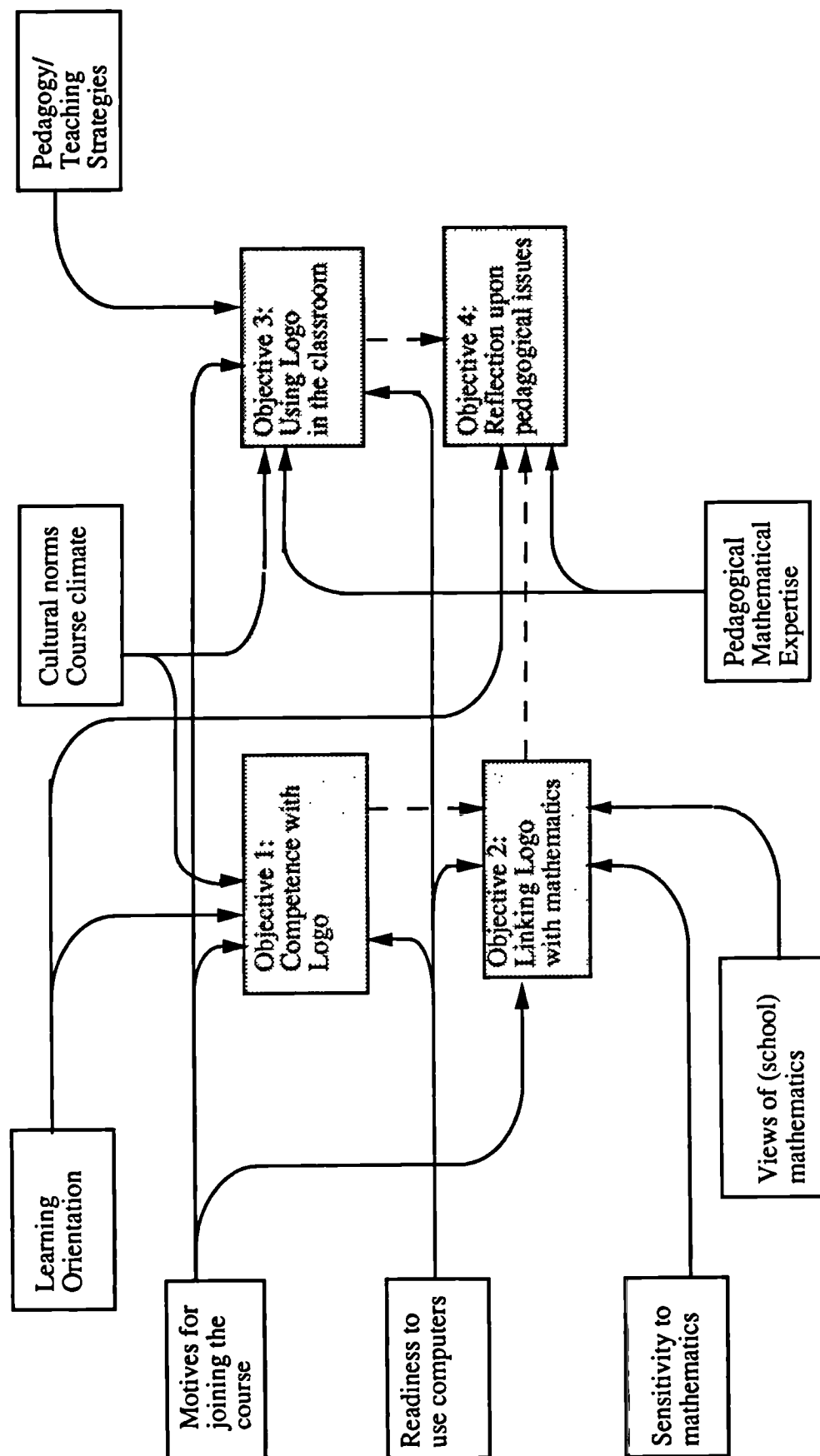


Figure 6.1: A Model of Teachers' Interactions with the Logo Course

hand, the extent and the nature of the participants' mathematical activity appeared to be dependent on the extent to which the participants were developing personal competence with the computer and Logo.

Five factors appeared to be associated with the third course aim, the development of confidence with and enthusiasm for using Logo in the classroom. One of the most important factors, or rather a set of interrelated factors, leading to the achievement of this aim is country specific: *course climate* and *cultural norms*. Two other factors are related to the participants' attitudes to and experiences associated with teaching mathematics: *pedagogical mathematical expertise* and *pedagogy/teaching strategies*. Finally, the two general factors, *motives for joining the course* and *readiness to use computers*, that were found to be associated with the two previous course aims, also seemed to influence the aim now under consideration.

It may be worth noting that no sharp relationship stands out between the participants' confidence in and/or enthusiasm for using Logo in the classroom and their development of personal competence with the computer and Logo. In fact, there were participants who developed considerable expertise with Logo and yet never came to show enthusiasm for using Logo with their pupils (e.g. John), as well as participants whose personal competence with the computer and Logo was quite limited and who nonetheless were still committed to using Logo in the classroom (e.g. Rosa).

Finally, two main factors seemed to affect the extent to which the participants' engaged in reflection upon pedagogical issues: *learning orientation* and *pedagogical mathematical expertise*. It should be noted, however, that given the inherent complexity of the issue, the mechanisms through which these factors led the participants to meet this course aim were not so clear. Moreover, it is important to point out that this aim seemed to correspond to the end of the causal chain. That is, the road to achieve this aim appeared to be a long one requiring several steps: (1) personal growth with the computer and Logo; (2) engagement in mathematical activity; and (3) development of confidence with and enthusiasm for using Logo in the classroom. In other words, should the participants fail to meet any of these intermediate steps, then the likelihood of their achieving the final aim was considerably limited.

Shifts in the participants' attitudes at the end of the Logo course

This section looks at the overall shifts in the participants' attitudes towards: (a) computers; (b) mathematics; and (c) mathematics teaching, associated with their involvement with the Logo course. The shifts that were brought about depended on the participants' initial attitudes and on how they responded to the course. Bearing in mind that no two participants entered the course

with the same motives, initial attitudes and experiences, neither did they interact with the course in similar ways, it is not surprising to find that shifts in their attitudes were also idiosyncratic. As in the previous sections, however, it was possible to identify some patterns related to isolated facets of the participants' attitudes that illuminate the kinds of shifts that occurred and what made them happen or not happen.

Shifts in the participants' attitudes towards computers

In spite of the fact that this research was not specifically concerned with the participants' attitudes towards computers as such, it was reasonable to predict from the outset that the participants' attitudes towards computers would be influenced by their participation in the Logo course. In fact, it turned out that shifts in the participants' attitudes towards computers appeared to be more pervasive (at least at the conscious level) than those in their attitudes towards mathematics or mathematics teaching. One may speculate that the participants' attitudes towards computers were less resistant to change than their attitudes towards mathematics and mathematics teaching, because they have arisen from at most ephemeral and shallow experiences.

The most significant shifts seemed to have occurred in relation to: (1) the participants' personal feelings towards computers; and (2) their views about the use of computers in mathematics.

Feelings towards computers

Using the computer and Logo throughout the period of the course seemed to have produced fairly widespread shifts in the participants' feelings towards computers (e.g. enjoyment, confidence). These shifts were more pervasive among the participants who had little or no experience with computers. Coming to know how to use the computer and using it for a considerable period of time led these participants to re-evaluate their feelings. An important mechanism for this reevaluation was a sense of personal achievement derived from the course activities. This stemmed from: (a) the development of personal competence with the computer and Logo ("I realised that I was making progress much more quickly than I expected to and I actually found that I was enjoying it ... I found that very satisfying" - Joseph, E) or (b) a sense of empowerment about using the computer in the classroom ("I feel an updated professional ... It's as if I had been promoted" - Ana, P).

On the other hand, many of the participants who were not greatly enthusiastic about computers, and whose motivation for joining the course was extrinsic (e.g. social influence motives), tended to experience a sense of failure and disappointment ("It's very tiring ... You know, in order to work with computers it's necessary to spend many hours before making them work. [...] I feel powerless in the face of computers ... I know very little" - Sara, P). Critical here

was a sense of mismatch between participants' own learning style and the approach adopted on the course. With its emphasis upon self-direction, the course might have introduced something totally new into these participants' frameworks as learners (and as teachers too). As a result of their loss of control and progress over learning, they faced embarrassment and felt demoralised.

Orientation to the use of computers in mathematics lessons

To judge from the rank order given to several statements related to the use of computers in mathematics, at the end of the course most of the participants considered the computer as a tool that can be used to explore and find out aspects of mathematics (in England) or to allow children to discover things for themselves (in Portugal). In general, this represented a shift from a view of a computer as a *moderniser* or as a *modifier* to a *change agent* perspective. Given the relatively limited opportunities for classroom-based work, such a shift has to be justified more in the light of the participants' own experience with the computer and Logo than in terms of their use in the classroom.

Of course, not all the participants came to regard the computer as a *change agent*. Some participants found many problems (due to varied reasons) in using the computer and particularly in programming with Logo. One may surmise that their focus in working with the computer was not so much on how it could be used in mathematics lessons, but rather on their personal involvement with it. The focus on programming with Logo may have led a few participants to choose to place an accent on the main role of the computer in mathematics as that of *developing reasoning skills*.

Two examples from the Portuguese participants will suffice to illustrate the different nature of the changes that occurred. The first is Clara, who shifted from seeing the computer as a 'drill-and-practice tool' to a means for children to 'discover things for themselves'. Her example illustrates the picture of a participant who entered the course with little interest in computers, but who had a considerable sensitivity to mathematics. The course presented Clara with the opportunity to engage in personally meaningful mathematical activity, as well as the prospect of obtaining a new post (as a collaborator with the MINERVA project). These opportunities triggered her commitment to the course and led her to reassess her attitudes towards computers in a direction akin to that advocated by the course.

The second example is that of Tânia. This participant, too, regarded the computer as relatively unimportant. Unlike Clara, however, she had a relatively low sensitivity to mathematics. Moreover, towards the end of her professional career, extremely confident in her ability as a teacher, Tânia appeared to have felt threatened by the presence of computers in schools. From

her "I have no idea" response to the question of the role of computer in mathematics lessons in the pre-interview, she came in the final interview to give preference to the view that the computer may make the teaching of the subject easier, interesting and attractive. Her viewpoint, however, was probably presented more clearly, when she commented:

What I'm interested in is that through this new tool (Logo or/and the computer) I can do what I'm supposed to do and for which I'm paid ... and that is to achieve what is in the curriculum, what parents, who are the school I clients, expect when they send their children to school ...

More than introducing something new into Tânia's perspective about the role of computers in mathematics, the course appeared to have acted to strengthen ideas and attitudes that she had probably been reflecting on.

Shifts in the participants' attitudes towards mathematics and mathematics teaching

As already suggested, shifts in the participants' attitudes towards mathematics and mathematics teaching appeared to be less substantial than in their attitudes towards computers. This was especially so with regard to the participants' feelings towards mathematics. That is, the participants tended to stay largely with their previous self-concepts about their enjoyment and confidence in dealing with mathematics.

As far as the participants' views of mathematics and attitudes towards mathematics teaching are concerned, however, more than half of the participants reported some form of change. As expected, shifts occurred either in the intended or in the opposite direction. Table 6.2 provides a rough summary look.

Table 6.3: Reported shifts in the participants' views of (school) mathematics and in their attitudes towards mathematics teaching

		<i>Have shifts occurred in attitudes towards mathematics teaching?</i>		
		<i>Intended Direction</i>	<i>None or Contradictory Changes</i>	<i>Unintended Direction</i>
<i>Have shifts occurred in views of (school) mathematics?</i>	<i>Intended Direction</i>	John Clara Debbie	Katie Emília	
	<i>None or Contradictory Changes</i>	Joseph Alice	Mark Laura Sara Joana Rosa Ana Tânia	David
	<i>Unintended Direction</i>		Paul Diana	

Only in three cases, those of John and Debbie (in England), and Clara (in Portugal), could it be said that the course had effects on both the participants' views of mathematics and their attitudes towards the teaching of the subject. It should be mentioned in passing that of these three participants, only John, who entered the course *committed to change*, seemed to be aware that he had been "changed" by the experience. For four more participants, Joseph and Katie (in England), and Alice and Emília (in Portugal), there was some evidence of shifts either in their views of mathematics or in their attitudes towards mathematics teaching. Looking at the negative side, one finds three cases with shifts which occurred in the unintended direction: Paul and David (in England), and Diana (in Portugal). The cases of David and Diana are specially interesting, since both seemed to have entered the course *committed to change* in their teaching of mathematics in a way that seemed in agreement with the essence of the course.

The following illustrates the kind of shifts which took place in the participants' attitudes towards mathematics and mathematics teaching, as well as those aspects that remained relatively unchangeable.

Participants' feelings towards mathematics

As already suggested, the participants' feelings towards mathematics appeared to be quite enduring. Thus, the participants who seemed to have always perceived themselves as enjoying and being good at mathematics continued to express the same kind of feelings after the course, even in cases in which their experiences with mathematics during the course were not successful at all. They were likely to attribute their difficulties and failures to something other than related to mathematics ("You know, I'm very fast when I'm doing calculations, but I'm very slow in typing ..." - Sara, P). By the same token, the participants who before the course started did not hide their lack of confidence and/or enjoyment in dealing with mathematics, tended to express the same kind of feelings at the end of the course. Again, this was so even in the cases in which the participants seemed to have enjoyed their involvement in Logo-mathematical activities and experienced success rather than failure during the course ("I think just doing it on the computer I've found that my attitude toward mathematics has changed... but I wouldn't say it has affected the way I look at maths in any other context ..." - Joseph, E).

A different picture was obtained from those participants who before the course started considered themselves in the present as fairly 'positive' and confident in dealing with mathematics, but who indicated a strong dislike for and low aptitude to the subject as pupils (e.g. David, E). Throughout the course sessions, most of these participants appeared to have felt inadequate in dealing with the Logo-mathematical activities. The picture that one gets here is one of a return to old attitudes to mathematics, and after the course, these participants' answers to the questionnaire and/or interview were reflecting 'negative' feelings towards

mathematics. Most interestingly, the majority of these participants failed to regard the course as mathematical.

Views about (school) mathematics

As stated earlier, at the beginning of the course, the course participants' views of (school) mathematics appeared to be in most cases not very strong. For many of the participants, the effect of the course was to clarify their own thinking and provoke rethinking of taken-for-granted assumptions. In some cases, this led to an apparent shift in the unintended direction ("Okay ... it [the course] might be mathematical, but I didn't see it in that way... [...] Well, I probably have, but not in my understanding of maths... [...] You didn't have to say... it was $4 \text{ squared minus } 2$... will give you the answer to this particular problem..." - Paul, E)

What might have caused such kind of reaction? In the absence of intrinsic motivation to become receptive to the course message and of considerable sensitivity to mathematics to respond to the mathematical stimuli provided by the course, these participants might have questioned their involvement with the course in terms of the time and effort they had to invest. Their experience with the course activated their consciousness of what mathematics is about and therefore uncovered views which had remained relatively dormant or obscured.

A different picture is presented by the participants with considerable sensitivity to mathematics. Clearly, for these participants, turtle geometry, programming with Logo activities, applying mathematics to solve concrete problems, were all mathematics. Incited by the course emphasis on self-directed and exploratory activities, they were able to make small leaps to new mathematical practices at the personal level. Throughout the course, their views of mathematics seemed to have moved from a formal and static perspective towards an informal and dynamic one ("... maths has a lot more to do with oneself personally rather than just an aspect of something you do on paper... [...] Maths is more than practising numbers on pieces of paper. It's an aesthetic subject which has got a great deal of fun in it..." - John, E).

A third scenario emerged among the participants with a relatively weak sensitivity to mathematics, but for whom the course was regarded as professional or personally relevant. Probably, at first, they, too, regarded their work as essentially graphical. However, over time, and as a result of increasing their confidence in using Logo and the computer, they came to engage in mathematical activity. ("All the time we're having to use maths in lots of different ways... and to write a procedure, wanting to reduce it to the most economical things, to do that you had to be very logical" - Joseph, E). This was especially so, in the cases of the *arts-oriented* participants who felt attracted by the graphical features of Logo. Interestingly, no matter how exploratory their activities were they appeared to have focused upon the reasoning involved in getting things done. This might have brought about or reinforced the idea that

mathematics is something that is highly logical and that "You can only understand mathematics if you have a logical mind".

A final comment on the participants' views of mathematics is worth making. As happened with the participants' feelings towards mathematics, some of their beliefs about mathematics appeared to be too deeply rooted in their experiences with mathematics as pupils (and as teachers, too) to be changed. One of the best examples of unchangeability is that of the prescriptiveness of mathematics, epitomised by the questionnaire item stating that "Each mathematical problem has generally a best way to get the solution". After the course, as before, the great majority of the Portuguese participants endorsed this item. Most insightful is probably the case of the only English participant (Joseph) who before the course started shared that opinion. At the end of the course, Joseph was still holding the same view, in spite of his engagement during the course in doing mathematics in his own way. His still vivid memory of a particularly bad moment in dealing with mathematics may shed some light on the issue:

We had a problem to solve and I worked it out and I got the right answer, but I worked it out in a very slow, very long-winded way, and the teacher when he worked out he did it very quickly [...] I felt a bit foolish... with all those children sort of teasing me...

Aims of teaching mathematics

At the end of the course, as before, the general picture of the participants' opinions about the aims of teaching mathematics was a diffuse one -- showing multiple and conflicting views. Such inconsistency, as already suggested, may reflect educational reality and is in itself an interesting finding. Despite the contradictory details, it was nevertheless possible to identify a couple of differences between of the pre- and post-pictures, suggesting that the opinions of some of the participants were challenged as a result of their involvement with the Logo course.

First, it seems that, at the end of the course, the participants were associating the endorsement of the affective aim with the extent to which they had had a successful and enjoyable participation in it. Excitement and a sense of achievement with the course led some participants who, prior to the course, had regarded the affective aim as relatively unimportant, to come to consider it as a priority ("I'd say (a) [the affective aim] is the most important one, because if you get (a), you're much more likely to get the others..." - Joseph, E). In contrast, poor experience with the course deepened the participants' cynicism. Thus, these participants who before the course had shown some sympathy with the affective aim, tended after the course to judge it as relatively unimportant.

Pedagogy/teaching strategies

In surveying the participants' answers to the questionnaire items addressing these issues, one can note two most common forms of shifts. One concerns the role of teacher -- from a *role*

model to a *facilitator*. The other is related to the participants' dependence on books and guidelines -- from a strong reliance on them to a weaker one. Interestingly, with a couple of exceptions when in the post-interview these participants talked about the possible influence of the course on their attitudes towards mathematics teaching, they were not very aware that any modifications had occurred. The comments of one of the participants (Joseph, E) are illustrative:

The course, I think ... reinforced my awareness of how valuable it is to find out things for yourself, but it did nothing to ahem ... sort of make me feel that I would be able to implement that more with the children apart from using the computer ... Like the basic maths, I'm still having to rely a lot on the textbooks.

One way of interpreting this kind of reaction is that the 'shifts' noted in these participants' answers to the questionnaire were primarily motivated by their own (relatively successful) experience as learners during the course. That is, these participants saw the course as advocating a self-directed and flexible approach to learning, and might have felt that such approach was a "valuable" one. Given the fact that the great majority of these participants did not invest much time in using the computer and Logo with their pupils, they could hardly recognise any evolution in their mathematics teaching strategies/pedagogy. It is possible, however, that the message conveyed by the course had some influence at the level of classroom instruction as well. Comments by Joseph, at a later stage of the interview, about the 'investigations' work he had done with one of his pupils and which he would probably not have done if he "hadn't been looking for those sort of patterns and relations in the course", illustrate the point.

The course appeared to have had more visible effects upon the participants who entered the course *committed to change* and who had a satisfactory involvement with the course (e.g. John, E). Here is how John assessed its influence on his attitudes towards mathematics teaching: "It [the course] has broadened my perspective and horizon on what can be used to teach a concept and hopefully make teaching more interesting". These participants were already concerned with their teaching in a way that was connected with the essence of the course. Therefore, they responded well to the course activities that were to foster reflection upon pedagogical issues, namely use of the computer and Logo in the classroom, group discussions, and the development of the Logo extended group project. They derived enjoyment, refreshment, fulfilment and challenge from their personal involvement with the course. Associated with this, they were gradually developing an awareness of a different way of teaching the subject, and at the end of the course, the participants seemed to be conscious that they had extended their views about mathematics teaching.

A contrasting scenario is represented by those participants who entered the course *committed to change* too, but who did not find in it what they wished to identify with. Their initial commitment to learn Logo and/or to use the computer and Logo with their pupils waned throughout the course, and they disengaged from the experience, if not physically at least psychologically. At the end of the course, they constituted a group of disillusioned participants. A look at their expressed opinions about teaching strategies/pedagogy reveals either no shifts or reversed shifts, that is, shifts in the unintended direction. An extreme example of a participant in these conditions is that of David. For instance, at the beginning the course, David commented: "The thing I enjoy particularly when it happens is when children find out that they can learn for themselves". At the end of course, he seemed to think in a different way: "... my experience is that at this sort of age children need immediate results ...". Once again, it is possible to suggest that these kinds of shifts were associated with cynicism reflecting these participants' disappointment with their involvement with the course. There is, however, a further interpretation. If what I could observe during my visits to these participants' classrooms was typical of their teaching strategies/pedagogy, then it is more likely that their views as expressed at the end of the course were already held prior to it, and that the opinions expressed before the course were probably no more than a form of wishful thinking.

FOUR MINI-PORTAITS OF ATTITUDE CHANGE

The mini-portraits described here are of two English participants (John and David) and of two Portuguese ones (Alice and Diana). (As already stated, more detailed pictures of these four participants are provided in Appendix F.1 through Appendix F.4). It should be noted that I had not planned to pay particular attention to these four participants. The following explains the reasons that led me to their choice. In addition to choosing the same number of participants in each country, three other criteria were used to select these teachers. Two of these criteria followed from the "Elaboration Likelihood Model" (ELM; Petty and Cacioppo, 1986) of attitude change that served as theoretical basis for the sub-study. Firstly, the teachers should have already experienced some "hurt" with regard to their teaching of mathematics, thereby being motivated to change their attitudes. Secondly, the teachers should be cognitively ready to use computers and Logo. The third criterion was of methodological nature: the teachers should provide contrasting cases, in order to depict better the variety of the findings from the sub-study.

The case of John¹

In his late 30s, John has been a primary teacher for 17 years. He has a Certificate of Education as his initial academic qualifications, and recently has been awarded a B.Ed. Honours degree. At the time of the Logo course he was teaching a class of second year juniors in an outer London primary school, where he has taught for 12 years. In the previous academic year he had taught infants, but he moved back into the junior sector. John, appeared to enjoy mathematics and feel reasonably confident with it. He has taken maths to A-level, and although he did not pass, his recollections of his experiences with the subject at that time did not appear to reflect any kind of resentment. He has considerable experience with computers, being the person responsible for computing in his school.

John was one of the participants whose experience with the course proved to be considerably successful in terms of achievement of the course objectives. All main ingredients necessary to a successful participation in the course were present in the case of John. First of all, he was highly motivated to attend the course: "It [the course] offers maths and computers... Two things..., one of which I perceive as a weakness, the maths side, and the other as an interest. Combining the two together, so it'll be convenient... ". His remark about being 'weak' in maths was most likely related to his role as a teacher of the subject: "It's probably the thing I teach worst [...] I think I enjoy teaching maths... whether the children enjoy me teaching maths is another question". It is possible that his recent enrollment in B.Ed. course had brought new ideas about teaching in general and encouraged him to question what he used to take for granted in his mathematics teaching.

Entering the course with a motivation for change, John was a willing and committed participant, who responded well to the challenges that it provided. In addition, his readiness to use computers together with his considerable sensitivity to mathematics, allowed him to feel secure and confident in its interactions with the computer and Logo. As a result, he increased his confidence and competence in using them and was able to use these tools to investigate mathematical ideas.

Moreover, as a primary teacher in the middle of his career, he might have felt some intellectual excitement from the freshness of some of the ideas offered by the course. He was especially sensitive to and enthusiastic about the idea of developing a Logo group project. In developing such a project (a microworld aimed at helping children to grasp the concept of angle), John appeared to have experienced genuine intellectual excitement, being motivated to gain new knowledge, reexamine ideas and challenge existing routines about how to teach the topic,

¹ See Appendix F.1 for a more detailed description of the case of John.

rather than restricting to use a cosmetic dressing of a familiar strategy. I interpret John's enthusiastic engagement with such project as a sign of reaffirmation of personal confidence and exercise of professional autonomy. At the same time, he could build upon his experience to feel comfortable in using Logo with his pupils as part of the course requirement. These two activities, the development of the Logo group project and the use of Logo in the classroom, seemed to have helped John to achieve a new understanding of pupils' mathematical learning.

Another essential factor in explaining John's success with the course was his orientation to learning. Notwithstanding the fact that he entered the course with an expectation that it would follow a traditional didactic approach, over time he came to accept its emphasis on self-direction and even to like it. In addition, John was particularly open to other people's ideas. This is well illustrated by his comments during the post interview, when he was asked to describe what stood out for him during the course:

Imagination of people. I think it's the thing I've found quite interesting and I've wondered whether I've got any.. when you see the imaginative ideas that people were using. The spiral, Joseph's spiral were really something else... and Debbie's using the turtles to move...

In short, immersion in a milieu in which John was encouraged to share ideas with others and contemplate alternative courses of action might have led him to reexamine his views about mathematics and mathematics teaching, which it seems he had already initiated before the course started. That the course offered him the grounding for developing a deeper appreciation of what he could do with the computer and Logo and fulfilled his expectations is quite evident from his comments in the post-interview:

I expected to learn how to use Logo, I learned that, I expected to find out what I was ... what I thought about it, that it was very powerful and that it was extremely complex and that you could use it to do a lot more than just draw pretty patterns... I expected it to be fun and it was... and I expected to meet interesting people and I did...

At the end of the course some shifts in John's attitudes could be noted. First of all, John's interactions with the course appeared to have enabled him to shift the view of the computer from a tool to support the curriculum to a means "to explore and find out" mathematics. Concomitantly, John's attitudes towards mathematics and towards the teaching of mathematics seemed to have evolved substantially. For example, in the post-interview, he commented: "What maths is has now become something greater than any sort of narrow concept I had previously... ". In particular, from a relatively *rule-oriented* perspective of mathematics, he appeared to come to view it as a creative subject that can be personally meaningful. As far as his attitudes towards the teaching of mathematics are concerned, John's confidence as a responsible professional capable of taking autonomous actions appeared to have increased. Moreover, he seemed to have moved away from a transmission approach to mathematics

teaching towards a negotiation mode: "I don't think that the teacher is in a didactic position any more. You're much more an enabler..."

The case of David²

In his late 30s, David was in his second year as a teacher in an infant school in south London. His main academic qualifications was a Certificate of Education (with English as main subject) that enabled him to teach at junior/secondary level. Prior to being an infant teacher, he had been a teacher in a secondary school, where he was the head of the department of English, for ten years. Recently, he had had the opportunity to do a diploma on the role of the language in an University Institute of Education. As part of his enrolment in this later course he had some practical experience in an infant class. This was all he had as formal experience to teach infants. His movement from the secondary to the infant sector, appears to be associated with a desire of trying to find an environment where he could be the teacher that he wanted to be:

I see what goes on in the infant school as being 2 or 3 degrees more valid than what goes on in the junior school. It strikes me that the further up the education system the children travel the less and less it's valid [...] At this level [infant] it strikes me that basically teachers are almost facilitators, you know, they're teaching someone how to do their shoelace or button...

It seems fair to characterise David as an idealist teacher. Implicit in many of his comments during the pre-interview there was a severe criticism of the formal school system in England. These feelings might well have been triggered off as a result of his experiences as a pupil. David recalled that he hated school, and that he was seen as a disruptive and subversive element when he attended Grammar school. In particular, it was clear that he strongly disliked mathematics and was not good at it when he was in school. It is significant that he was unable (unwilling?) to recall any specific incident in which he felt specially bad in dealing with the subject, since "most of the time numbers made me feel bad".

Meanwhile, his feelings towards mathematics appeared to have evolved towards a more neutral position. As he put it: "I now feel since I've been working with infants very, very positive about it". It is possible that as a result of his recent experience of teaching the subject to infants, David has been pushed to view the subject in a "different light" and is full of new ideas about it: "It's a whole new way of viewing maths and it's becoming, and it strikes me that in London now it's become more and more creative, that might be just because I'm new to it". However, the weight of evidence suggests that David's 'new' views of mathematics and feelings towards the subject were somewhat fragile. Or even they were no more than an expression of a defense mechanism. It was possibly because David had to teach a subject that he disliked intensely in

² See Appendix F.2 for a more detailed description of the case of David.

the past that he had to convey 'false' attitudes consistent with his utopian educational world. It may be worth recalling here the incident occurring during the pre-interview when David was asked about the role of computers in mathematics. He reacted strongly remarking that "computers do not necessarily have anything to do with mathematics". My interpretation of David's reaction is that it is reminiscent of his feelings towards the subject. Anything that has any ostensible connection to mathematics is automatically considered bad, and so David rejected seeing that link.

David has welcomed the presence of computers in schools and has already got considerable experience with computers. Two major factors seemed to lie behind David's motivation to incorporate computers into his teaching. First, David's personal interest in using them was based on one particular usage of computers -- their utilisation as a word processor -- and related to his special inclination to language arts. Second, it stemmed from his vision of computers as potential tools to reform schooling. This latter viewpoint is apparent in the following comments when he stated his motives for joining the Logo course: "I'm interested 'cos I want to know how it [Logo] works... and what *it can do for me* [my italics]... I've begun, I suppose, to see possibilities... That began with Mindstorms and Seymour Papert on television... That began to open doors for me... "

Along with his interest in attending the Logo course, David was suspicious of what it had to offer him. In line with his self-prophecy, throughout the course he felt frustrated and resented the course approach. In assessing his participation in the course, he commented:

The short answer is that I felt very comfortable... the long answer is that I felt more comfortable at different times, ahem... one thing that come to mind is that I found... without... I don't really want to mention names, but I found it easier to work with some people rather than others... [...] one occasion I felt... I felt in a sense that I was wasting my time and that came out not so much in what I was doing but how I was finding it difficult to relate to the person I was asked to work with...

His loss of interest in and disillusionment with the course seemed to have resulted from three developments. First, throughout the course sessions David was not in control of the Logo-mathematical activities. David's immersion in a mathematical learning environment might have brought to the surface past feelings of anxiety and helplessness in dealing with mathematics. These feelings appeared to have been exacerbated by lack of mathematical knowledge, as well as the course approach emphasising self-direction. A second development was associated with his lack of experience as an infant teacher -- he felt inadequate with the course focus on partnership and responsibility, and consequently the potential of the learning experiences was reduced. Third, it is possible that his natural pessimism about the educational world was itself a prime difficulty for David during the course.

At the end of the course, there were some reversals in David's expressed attitudes in the direction opposed to that of the message conveyed by the course. Some of these reversals were clearly a form of expressing his disappointment with the course. For example, he came to show agreement with the idea that the primary reason to teach mathematics is having children to perform well in curriculum specified tasks. On the other hand, at the end of the course, he appeared to be more willing to admit his "block about maths" than he was before: "When I was taught my maths was a disaster, so I *have* [my italics] a kind of prejudice, you know, that I can't learn". In addition, David appeared to have lost some of his earlier idealism about mathematics and mathematics teaching, and increased his awareness that he was not good at teaching the subject:

I would like to see children getting as much joy from maths, as much excitement from it as they do about painting or making models... Ahem... and it's... I think it's poor teaching that stops that... and I am probably very poor at teaching maths but that's an ideal world... how I would like to think of maths...

The case of Alice³

In her mid 40s, Alice has been a primary teacher for more than 25 years, eight of which are in her current school. At the time of the Logo course, she was teaching a class of fourth graders. (As is common practice in Portugal, Alice has taught these pupils through their four years of primary schooling). Her school is located in a urban area in the outskirts of Oporto. Although committed and dedicated to her profession, Alice was probably not fully satisfied with it. She has not had other professional experience besides teaching primary school children, but teaching did not seem to be her vocation. Looking back to her decision to become a primary teacher, she remarked that she would have rather preferred to go into something related to the arts and that she had yet relinquished this aspiration (to do something related to arts).

The advent of computers in education in Portugal might have tapped into Alice's relative frustration with her job and her aspiration to do something different. She belonged to the first wave of teachers who volunteered to implement computers in primary schools in Portugal as part of the national project to introduce them in schools (MINERVA project). She described herself as "fascinated and attracted" by computers.

On the other hand, Alice's feelings of enjoyment of and confidence with mathematics seemed to be relatively lower than those of the majority of the Portuguese participants. She spoke of hating the subject and finding it difficult when she was in school, and even of wanting to give up studying because of maths, but she was able to get the equivalent to O-level in the subject. Her enthusiasm for and confidence with teaching mathematics appeared to be modest as well:

³ See Appendix F.3 for a more detailed description of the case of Alice

Now, I like to teach maths but I notice that children generally don't like it. It's surprising... I always try to teach... to give them the best insight possible so that they understand... And they are able to do mathematics, but they don't like it. Maths demands a considerable effort from them... I don't know whether it's because they have mental laziness... Maths demands the learning by heart of tables, doing calculations... All of that is probably too dull for them...

With no other qualifications to teach mathematics than those she acquired 25 years ago during her initial training as a primary teacher, Alice might not have had the opportunity to develop her interest in the subject and had probably brought her mathematics teaching to a standstill.

Enrolling in the Logo course provided Alice with the avenue she needed to challenge her attitudes towards mathematics and mathematics teaching with which she appeared to be already uncomfortable. Although on entering the course she was not primarily concerned with mathematics, she was prepared to justify to herself the necessity of making a mathematical input during her involvement with the Logo course. Her trajectory in the course was most influenced by her strong personal enthusiasm and confidence in using computers. The computer and Logo captured and sustained her interest during the course, and enabled her to reshape her attitudes to mathematics. In particular, her personal enthusiasm for the computer seemed to have spilled over into a desire to engage in Logo programming activity. Moreover, entering the course with more experience than the other participants seems to have helped her to feel comfortable and resourceful, thus increasing her self-confidence. This might have acted as a catalyst for increasing her knowledge of Logo and improving her performance. Alice was undoubtedly much more at ease with the computer than the other Portuguese participants, produced more work and came to display more knowledge of Logo programming features than most of them.

In addition, the relative freedom and flexibility offered by the course approach matched Alice's orientation to learning, and she came to develop a deeper appreciation of dealing with mathematics. Feelings of sense of pride and satisfaction were reflected, for example, in her post-interview remarks about the "Investigating Stars" (see Appendix D.10) activity: "I didn't have time to do it during the course sessions, but I did it here in school... I found it very stimulating... I had to use my brains a lot, I had to do a lot of calculations, but it was quite satisfying and fun...". The course also provided her with the grounding of a new kind of cognitive and metacognitive mathematical literacy. As the course progressed, she had to evolve her perspective of Logo and mathematics in order to accommodate to the kinds of activities that were suggested. At the end, Alice appeared to have shifted away from a predominantly rule-oriented perspective of mathematics to a more problem-solving one.

Alice's involvement with the computer and Logo during the course had, however, two major unintended effects. The first is that with a relatively weak background in mathematics, Alice

seemed to have found some of the features of programming with Logo difficult and demanding a lot of effort. As a result, she came to consider that mathematics is a subject suited for people with a special mind. The second effect involves what might be called excessive personal involvement with the computer. At the beginning of the course, Alice indicated that she was mainly interested in the applications of Logo in the classroom. As the course progressed, however, she appeared to have developed more interest in growing her own competence with the language. Her comments in retrospect in the post-interview confirm this tendency: " my expectations at the level of what I have to teach in school were completely fulfilled... but what I want to know goes beyond what I have to do with pupils... It's out of my own personal interest... Because I'm eager to know things... ".

A disadvantage of this development is that it appeared to have curbed Alice's ability to participate fully in the course activities focussing on the use of Logo by children and hindered her reflection upon pedagogical issues. Thus, a really serious effect of Alice's participation in the Logo course on her attitudes towards the teaching of mathematics was still a long way off at the end of the course. There was, nevertheless, at least some evidence that the course produced some perturbation in those attitudes. The possibility remains that shifts occur as Alice's experience in working with the computer and Logo in the classroom accumulates. As she put it: "things take time to percolate..."

The case of Diana⁴

Diana, in her late 30s, has been a primary teacher for 16 years, 14 of which in her present school in Oporto city. At the time of the Logo course she was teaching a class of second graders. The type of the school, a private catholic school, is an important factor to take into account in analysing the case of Diana. Indeed, although the curriculum followed by the school is the same as the official one, the characteristics of the school are quite different from those of state schools. For example, the school enrolled children from kindergarten to ninth grade who mainly come from middle to high social class families. Moreover, in contrast with what happens in schools in the state sector, teachers in Diana's school are hired by the head. Under these conditions, a school pedagogical orientation is likely to be encouraged and highly valued by the head (and parents).

Diana can be portrayed as a traditionalist teacher who appeared to have experienced some frustration after having taught the same again and again in the same school. It may be interesting to note that at a certain point of her career as a teacher, Diana considered quitting the profession. At the time of the Logo course, however, she seemed to have an unequivocal

⁴ See Appendix F.4 for a more detailed description of the case of Diana.

commitment to her job, yet feeling some disappointment derived from the constraints and lack of opportunities associated with it.

No longer finding her job satisfying, Diana appeared to have incorporated the computer into her teaching as a chance of bringing some fresh air to her professional life. In taking advantage of parents' social background, participation, and involvement with children's school life, she managed, with the approval of the school head, to buy two small microcomputers for her class. She was the first and only teacher in her school to do so. She has been using computers with her pupils for about one year. Nevertheless, in so doing Diana evidenced little realisation of the potential of computer for creating qualitatively different kinds of learning environments.

In joining the course, Diana seemed to be primarily interested in broadening her perspectives of how to use Logo in school. To a lesser extent, Diana, too, appeared to have seen the course as a means of redefining her teaching of mathematics within the context of a computer environment. Indeed, she seemed to have reached a stage in which she was no longer satisfied with her approach to teach the subject:

To tell you the truth I teach mathematics in a way that I don't like. May be I'm compelled to do so owing to constraints such as time, the curriculum..., but I think that I teach in a very structured way. I try to be less structured as possible, but I reckoned that it is still quite structured...

Diana's responses to the attitude questionnaire and interview before the course started portrayed her as someone who has greatly enjoyed and felt confident with mathematics. It is somehow paradoxical that she had developed this self-image. Indeed, she did not pass her equivalent to O-level in mathematics. Moreover, at one point during her career as a teacher, she thought she wanted to get the equivalent to A-level in mathematics, but then she encountered some difficulty in what she called "modern mathematics" and lost interest. One may speculate that the appeal that mathematics held for Diana as a pupil was laid in traditional paper-and-pencil exercises of imitative nature.

Diana's preparation to teach mathematics that she obtained at pre-service level did not appear to have any considerable effect on her attitudes towards mathematics. According to her assessment, such preparation was very bad:

It was awful... We used to spend the time building games to teach mathematics, but that did not give us the sense of practical terms, you know, the kind of things that we needed to teach the kids... I didn't learn anything...I didn't learn anything more than I had learnt when I was doing my O-level... I would like to go into a teacher training course again, so that I could learn more...

These comments are in consonance with her narrow view of the scope of mathematics and mathematical activity, and point to a narrow conception of its teaching.

SUMMARY

This chapter has contained a general pass through the cases of seven English primary teachers and ten Portuguese ones who attended in two different settings (respectively in London and Oporto) a similar Logo-based mathematics in-service course. The intention has been to provide a sense of primary teachers' attitudes towards mathematics and towards mathematics teaching in the context of their involvement with such a course, and of how and why these attitudes evolved (or did not evolve) as a 'result' of such involvement. The cross-country approach used has allowed to point to two main findings. First, it has strengthened the results of the first sub-study suggesting that cultural, social and political issues are extremely important in influencing how primary teachers perceive mathematics and its teaching. Second, by showing consistency as to the ways in which the attitudes of the participating teachers in the two countries evolved (or did not evolve), it has offered some support to the emergence of a unified theory of attitude change. Thus, it has indicated a range of factors (of which culture is also part) that might facilitate or hinder the process of change in teachers' attitudes towards mathematics and mathematics teaching, as well as the aspects of those attitudes which are most likely to be modifiable or in contrast unchangeable.

Given the considerable number of factors involved and the complex interactions among them, the effects of these factors were judged to be clarified and better understood by analysing individual cases. Thus, the chapter has ended with the presentation of contrasting mini-portraits of attitude change, two in each setting. These individual cases have also illustrated that in addition to the factors previously identified there are other powerful idiosyncratic determinants of teachers' attitudes which might hinder or facilitate change (e.g. school culture).

CHAPTER 7

The pursuit

(Conclusion)

Age wastes away and losses multiply;
A remedy I had begins to go;
If from experience I seek to know
Any great hope I kept is a great lie.

Camões¹

In this chapter, I reflect back on the purpose of this study and the procedures used to undertake it, and I review some of its most relevant findings. In an expected way, this study has some limitations and is incomplete. I will acknowledge such limitations and point out directions to be explored by future enquiry. Finally, the last part of the chapter assesses the contribution of this study to the development of mathematics education.

PURPOSE AND CONCEPTUALISATION OF THE RESEARCH

As stated in Chapter 1, the purpose of the study was threefold:

- to investigate primary teachers' attitudes towards mathematics and towards mathematics teaching, and as a subsidiary aim to examine factors that might account for these attitudes;
- to examine ways in which primary teachers' attitudes towards mathematics and mathematics teaching, along with other factors, influenced their participation in a Logo-based mathematics in-service course;
- to ascertain the degree to which primary teachers' attitudes towards mathematics and its teaching were influenced by their participation in a Logo-based mathematics in-service course.

¹ This is part of the translation of the poem *The Pursuit* of Luís de Camões c. 1524-1580), the 'national poet' of Portugal, published in Taylor, 1990.

My starting point for the enquiry was a thorough review of literature which was presented in Chapter 2. Topics examined included perspectives on attitude and attitude change, and in-service training for teachers, as well as research on teachers' attitudes towards mathematics and mathematics teaching, and teachers' learning and teaching experience with Logo. The term *attitudes*, as used in the study, focuses on people, objects and issues, and brings together thought, action and emotion. In turn, teachers' attitudes towards mathematics and mathematics teaching were conceptualised in Chapter 3 in terms of several areas judged useful to understanding how primary teachers deal with the subject and its teaching. These included: (a) teachers' views about mathematics and school mathematics; (b) their personal feelings towards mathematics in terms of both enjoyment and confidence; (c) their perceptions about the importance and usefulness of mathematics; (d) their opinions about the aims of teaching mathematics in primary school; (e) their pedagogy and teaching strategies; and (f) their opinions about the role of computers in children's mathematical learning.

In parallel with the conceptualisation of teachers' attitudes, three theoretical principles to orient this study were identified (Chapter 3). In brief, these principles were:

- attitudes can be understood only as the history of attitudes;
- attitude change can be understood only as the history of change; and
- the main agent for educational change is reflection.

Following on these principles, six major sets of variables related to the phenomena under investigation were posited (Chapter 3). Finally, these sets of variables were integrated into a loose conceptual framework to be used as action guidelines to the research.

A two-country "zooms lens" design was then envisaged to carry out the investigation (Chapter 3). It consisted of undertaking two independent sub-studies in England and Portugal: (1) an attitude survey, and (2) a developmental study of attitude change having for basis a Logo-based mathematics in-service course.

Before the fieldwork could take place, the research tools to be used in the research were developed (Chapter 4). These included an attitude questionnaire which was used in the first and second sub-study and the design of the Logo-based mathematics in-service course.

MAIN FINDINGS AND DISCUSSION

This section of the chapter summarises the main findings of this study. It includes five main sub-sections organised according to the three main goals mentioned above. The first subsection focus upon the findings related to the comparison of the attitudes towards mathematics and mathematics teaching of primary teachers in England and Portugal bringing together the results from both the first and second sub-studies. The second through the fourth sub-sections provide an overview of the findings concerning the teachers' interactions with the Logo course. The final sub-section reviews the findings associated with the shifts in the teachers' attitudes at the end of the Logo course.

Primary teachers' attitudes towards mathematics and mathematics teaching

From the overall research program, it was clear that there were considerable differences and a few similarities between the attitudes of primary teachers in England and Portugal. The differences concerned: (1) the variability of teachers' attitudes; (2) their views of (school) mathematics; (3) their opinions about the aims of teaching mathematics; and (4) their pedagogy and teaching strategies.

The variability of teachers' attitudes was less pronounced among the Portuguese teachers than among the English ones. This finding is in agreement with the hypotheses raised by Travers (1980) concerning the two following factors: (1) the existence of a national curriculum in Portugal; and (2) the existence of limited resources in schools and facilities for teacher education in this country.

The English teachers were more likely to perceive mathematics as a fallible and problematic body of knowledge than the Portuguese ones. It appears that the curriculum development projects that have taken place in England in the area of school mathematics over the last thirty years have influenced to a great extent English teachers' perspectives of mathematics. This finding suggests that it is possible to challenge teachers' traditional views of mathematics. A crucial factor in imparting a view of school mathematics as a dynamic and creative subject (in addition to the nature and emphasis of the curriculum movements) is the assistance that the teachers received once the curriculum changes were under way.

The Portuguese teachers tended to agree to a greater extent than their counterparts in England with the fact that curriculum goals become ends in themselves rather than means. The induction of pupils into further mathematics seemed to be of considerable importance for the vast

majority of the Portuguese teachers and of relatively little importance for the English ones. The English teachers appeared to pay much more attention to affective outcomes than the Portuguese ones. Once again, the existence of a national curriculum in Portugal, along with the fact that pupils at the end of each grade have to attain certain standards to pursue the following grade, assumes a prominent place in the opinions of the Portuguese primary teachers. In turn, the focus placed on practical activities and games by mathematics educators in England provides a basis for English teachers considering mathematics a subject that can and should be enjoyed.

The Portuguese teachers tended to emphasise the learning of mathematical facts and the practice of basic skills. The vast majority of the English teachers, in contrast, seemed to attach little weight to having their pupils practising basic skills and be more sensitized to mathematical activities of both a practical and open-ended nature. In the absence of other advice, the Portuguese teachers were likely to teach as they have always taught before and what they feel comfortable with, focussing upon the more formal parts of mathematics. Even the utilitarian aspects of mathematics (with regard to both applications to everyday life and links with other subjects) appeared to receive little attention.

The English primary teachers showed a preference for teaching mathematics to ability groups or to individuals. In contrast, whole-group instruction seemed to be the primary method used to teach mathematics by Portuguese primary teachers. It is reasonable to think that the preference of the teachers in Portugal is associated with the uniformity of the school system in the country and represents an attempt to ensure that all the pupils are provided with the same content and methods in order to achieve the standard goals laid out by the national curriculum. The preference of the English primary teachers, in turn, can be seen as part of the ethos of primary schools in England: pupils work independently at their own pace, but with plenty of room for interaction and cooperation. The difference between the teachers' preferences in the two countries may also be a function of differences in their convictions about mathematics.

A few similarities between the attitudes towards mathematics and mathematics teaching of the English primary teachers and the Portuguese ones were also revealed. These include: (1) their perceptions of the utility of mathematics; (2) inarticulateness of their views of mathematics; and (3) conflicting opinions about the aims of teaching mathematics.

In both countries, the vast majority of teachers tended to consider mathematics a very important subject to study in terms of its applications to everyday life, jobs and the study of other subjects. It seems reasonable to attribute such similarity to the almost universal strong traditions about the place and importance of mathematics in the primary school curriculum.

In both countries, the primary teachers' perceptions about what mathematics is about were to a great extent vague and inarticulate. Moreover, the teachers' thinking about mathematics rarely seemed to reflect either an integrated view of the subject or an awareness of the distinction between mathematics and school mathematics. Not unexpectedly, during the interviews, most of the participants in the second sub-study found the question addressing this matter a difficult one, and some of them reckoned that they had never thought about the issue before. In other instances, they offered perspectives that were apparently inconsistent with their opinions expressed through the attitude questionnaire. This might be the result of a conflict between the conceptions of mathematics predominantly formed as an amalgamation of influences associated with their own education from the time they were in school and new views developed in relation to school mathematics resulting from their experiences as teachers. It seems appropriate to suggest that primary teachers' training programmes, both at in- and pre-service level, have been rather superficial to foster reflection upon these issues among teachers and future teachers.

In both countries, the primary teachers' opinions about the aims of teaching mathematics seemed to be weakly held. The teachers tended to express multiple, often inconsistent aims. Even if one accepts that goals conflicts and dilemmas are inherent to schools, it does seem reasonable to conclude from the comments of the teachers participating in the second sub-study that they had spent very little time actually reflecting upon why they were teaching mathematics. Just as primary teachers were earlier considered to have reflected little about what mathematics is about, their positions on the reasons for teaching mathematics in primary school seem to remain largely unexamined. This lack of reflection upon theoretical questions and issues is line with suggestions of other authors pointing to that “teachers are primarily confronted by practical problems” (Clark and Yinger, 1987, p. 98).

The teachers' interactions with the Logo course

There are two main general conclusions when the interactions of the teachers with the Logo course are viewed in the light of a cross-country perspective. First, the teachers' responses to the course in England and in Portugal differed greatly. Second, one of the most fascinating findings of the second sub-study was that when the participation of the teachers in England and Portugal were compared (not in absolute levels but in terms of how their interactions with the course evolved) there seemed to be a fair degree of similarity as to the conclusions reached in the two countries. In a later sub-section, a model is presented that attempts to pull together the findings from the two countries. In the remainder of this sub-section, some of the main cross-country differences concerning the teachers' interactions with the course are reviewed.

The English teachers (as a group) produced much more Logo work and achieved a higher level of competence with Logo than did the Portuguese ones. Although this fact is likely to be associated with several factors, I believe that it is above all related to the considerably different degree of experience with computers of the two groups of teachers. Still another important factor may lie in the course theoretical orientation with emphasis upon self-direction and diversity.

The kinds of mathematical activity in which the two groups of teachers were engaged throughout the course differed considerably. For instance, in drawing with the Turtle during the earlier course sessions, the English participants were more accurate in their estimations of *distances* and *angles* than the Portuguese ones. The most distinctive feature among the two groups of teachers was, however, their response to the investigatory activities proposed during the course sessions. It was evident that these kinds of activities were unfamiliar to the Portuguese teachers and they hardly recognised them as of mathematical nature. Undoubtedly, these differences can be in part attributed to the different views of (school) mathematics held by the teachers in England and Portugal, which are informed by their distinct experiences in teaching the subject (greater emphasis placed in practical activities and tasks of open-ended nature within primary mathematics in England than in Portugal).

The Portuguese teachers appeared to be more concerned with their performance compared with that of their fellows than the English ones. Moreover, the Portuguese teachers tended to engage in more off-task socialisation than the English teachers. In fact, within the English course situation, relatively frequent comments of appreciation of other peers' work took place. Moreover, interaction, co-operation and help, both among the individuals and among the different working groups, often occurred. This proved to be very effective in fostering the English teachers' growth with Logo. This is in marked contrast with what happened in Portugal, a finding which agrees with the contention of Bradley (1987) suggesting that in countries with centralised educational systems, staff development programmes that expect collaboration between teachers may not be welcomed by the participants. On the other hand, the Portuguese teachers seemed to enjoy breaks and used them to exchange information about the most varied topics. In England, interactions between the teachers were almost entirely task-oriented.

The Portuguese teachers were more enthusiastic about using Logo with their pupils, seemed to have put more time and effort in this activity, and were more accepting of visits to their classrooms than the English ones. It is possible that the sheer presence of the computer through its novelty triggered off feelings of "being promoted" among the Portuguese teachers, and therefore generated considerable enthusiasm. Coupled with their greater enthusiasm due to the

innovativeness of the situation, the reactions of the Portuguese teachers to this course activity may have been driven by authoritative norms (e.g. compliance with authority).

In sum, the current research has indicated that there are many aspects of culture that are brought to bear, both directly and indirectly, in the ways teachers respond to a learning/teaching experience in the context of an in-service Logo-based mathematics course. The cross-country component of the study, by highlighting differences and similarities between the teachers in the two settings, constituted a valuable context in helping to understand the events that unfolded throughout the Logo course and to identify the factors that accounted for the participants' reactions within the same setting.

Factors which accounted for the teachers' interactions with the Logo course

As suggested earlier, while the attitudes towards mathematics and mathematics teaching of the teachers in England and in Portugal differed considerably along with their interactions with the Logo course, the processes through which changes in those attitudes occurred (or did not occur) in the two settings were similar. The consistency of these changes across the two countries led to the conclusion that similar factors were underlying those interactions. In what follows, a summary is presented of those factors that appeared to be more pertinent to the understanding of the teachers' responses to the course .

As a starting point for examining which factors would account for the teachers' interactions with the course and subsequent changes in their attitudes, I adopted the 'Elaboration-Likelihood model' proposed by Petty and Cacioppo (1986). Such a model proved to be helpful in understanding what the teachers did (or did not do) during the course and how their attitudes evolved throughout it. Consistent with that model, I found that, despite the fact that how the teachers interacted with the course was an individual matter, there were several factors that seemed to recur and generate similarities in several domains. According to this model, the likelihood of elaboration of a persuasive message is determined by a person's motivation and ability to evaluate the communication presented. Elaborating on this contention, I identified six major factors associated with the teachers' interactions with the course, and in particular with the extent to which they met the course objectives: (1) *motives for joining the course* (e.g. personal agenda, practitioner, social influence, commitment to change); (2) *readiness to use computers* (e.g. previous experience, feelings, existence of appropriate equipment in their schools); (3) *sensitivity to mathematics* (e.g. mathematical background, feelings); (4) *views of (school) mathematics*; (5) *pedagogical mathematical expertise* (e.g. primary teaching experience, academic and professional qualifications); and (6) *teaching strategies and pedagogy* (e.g. conditions created and means used in their classrooms).

In addition to the six factors akin to those in Petty and Cacioppo's model, I identified another pervasive and powerful element in determining how the participants interacted with the course: their *learning orientation* (e.g. autonomous, conformist). Finally, further important factors for understanding the participants' response to the course at group level were the *course climate* (e.g. working arrangements, scheduling, equipment) and *cultural norms* (e.g. tolerance of diversity, collaborativeness, socialisation) power structure).

Tying the threads together: Towards a model of teachers' interactions with the Logo course

In addition to identifying factors which accounted for the teachers' interactions with the Logo course, it was recognised that: (a) those factors had different functions in shaping those interactions; and (b) they were not equally important for the forming of the participants' responses to the course.

Thus, as a result of the sub-study a tentative model was sketched (Chapter 6) that attempts to link the factors identified with the teachers' interactions with the course, namely with the ways in which they met or did not meet the course objectives. It must be stressed that although the model emerging from my analysis yields explanatory accounts that make good logical and empirical sense, it only represents a loose conceptual framework of the teachers' interactions with the course. In other words, such model cannot be interpreted in the sense of being strictly predictive. A weak side of the model, for example, lies in that it does not capture the fact that those interactions are a combination of the contributions of the several factors identified. In fact, it must be recognised that these factors are interdependent and linked in intricate and complex ways. Moreover, it hides the fact that other factors (as, for example, school related variables) might have an equally important role to play.

Factors associated with teachers' development of competence with Logo

The most basic course objective was to have the participating teachers building competence with Logo. Strictly speaking, only when the teachers were able to function competently with Logo could they meet the other course objectives. Three factors were viewed as having an effect on the teachers' development of competence with Logo: *readiness to use computers*, *learning orientation*, and *motives for joining the course*.

Success in developing competence with Logo throughout the course was strongly related to the teachers' readiness to use computers. Using the computer was, in fact, problematic for many teachers who did not have previous experience with it. At the end of the course, most of the teachers who showed considerable knowledge of Logo were those who were familiar with

computers prior to the course. This finding is in contrast with those of the few previous studies (Ferre, 1983; Mitchell, 1983) which suggested that learning Logo is irrespective of previous computer experience, but in agreement with Hoyle, Noss and Sutherland (1991).

The teachers' development process of competence with Logo tended to be protracted, especially in those cases in which the teachers' orientation to learning differed considerably from the course orientation. The structure of the Logo course was based on several assumptions about teachers' professional development, one of which was that this is best cultivated through an approach emphasising active participation and self-direction. Data from this study indicate that the effectiveness of such an approach in terms of teachers' growth with Logo is mixed at best, as not all the participants were able to adjust to it. While for some teachers the gap between the course orientation and their own orientation to learning seemed to be narrow and could be crossed more or less easily, for others the gap was wider and they had a difficult time getting used to the approach. Some teachers became disillusioned because their progress was slow.

The teachers were more likely to show a strong involvement with the course (at least during the earlier sessions) and develop competence with Logo when they had an initial commitment to change their teaching or career-related motives were operating. That is, as with any enterprise, success was closely associated with the participants' motivation. In some cases, however, initial commitments did not develop as much as they seemed to promise. As a result of other factors (e.g. learning orientation, sensitivity to mathematics), some teachers confronted problems and difficulties in the course that they did not expect, and then experienced frustration and loss of confidence.

Factors associated with teachers' ability to link Logo with mathematics

The Logo course environment did provide a means by which teachers could engage in a range of mathematical activities. Of course, the extent to which the teachers were able to engage in such activities was constrained by the achievement of competence with Logo. Moreover such ability seemed to be related to four factors: *sensitivity to mathematics, views of (school) mathematics, motives for joining the course, and readiness to use computers.*

The content and processes of the mathematical activity undertaken by the teachers in the Logo course were related to both their mathematical background and their feelings towards mathematics. When the teachers had a considerable sensitivity to mathematics, they could move on from the beginning of the course to conceive their Logo work as mathematical by integrating their previous knowledge with their programming activity. In other words, their mathematical meta-knowledge enabled them to understand the mathematical nature of the Logo activity. They

were also able to become involved in the more complex features of Logo programming such as use of variables, recursion and control structures, and use them to explore mathematical ideas. In contrast, the teachers with weaker sensitivity to mathematics were less likely to regard their Logo activity as 'real' mathematics, and found it difficult to grasp those aspects of Logo. In particular, those teachers who were burdened with unpleasant memories of past experiences with mathematics in school tended to carry over into the course these negative feelings and this affected their ability to respond to the mathematical stimuli provided by the course activities. Reentering a learning situation in which they had to deal with mathematics resulted in their experiencing helplessness about mathematics and fear of failure, thus acting as learning barriers and preventing from developing a more positive attitude about themselves. However, there were also a few teachers with a relatively weak sensitivity to mathematics who found in the course a means for changing their affective experiences with the subject. This was more likely to occur with the 'arts-oriented' teachers who felt specially attracted by the graphics aspect of Logo.

The relationship between the teachers' mathematical/computational activities during the course and their expressed views of mathematics was only a precarious one. Part of this may be due to the fact that these views were in most cases not very strong. Nevertheless, the teachers' interactions with the course cannot be said to be unrelated to their underlying views of (school) mathematics. As stated above, important differences were revealed when the interactions of the teachers in England and Portugal were compared, which could be attributed to the different experiences they have had in teaching the subject in the two countries.

There was a strong relationship between the teachers' ability to use Logo as a tool to explore and do mathematics, and their confidence and competence in utilising the computer. The teachers who were already familiar with computers or who came to develop considerable confidence in using them throughout the course tended to see themselves able to cope with the mathematics involved in the course activities and to enjoy taking risks to explore mathematical ideas.

The extent to which the teachers engaged in mathematical activity and saw their Logo work as of a mathematical nature was related to their motives for joining the course. The teachers for whom the use of computers was an almost completely novel experience were in general less interested in the mathematical aspect of the course than in the fact that it was a course involving computers and Logo. In contrast, those teachers who joined the course with a specific interest in the mathematics that the course had to offer showed a greater involvement with the course's mathematical activities. What these participants found on the course was close to what they wanted and this contributed to increase their commitment to it.

Factors associated with using Logo in the classroom

The teachers' use of Logo with their pupils in the classroom as part of the course requirement was not extensively scrutinised and therefore estimates of the success of the course in stimulating them to do so are necessarily tentative. Three major factors were seen as essential for maximising the teachers' enthusiasm for and commitment to such a requirement: *motives for joining the course, mathematical pedagogical expertise, and readiness to use computers* (in the form of the existence of appropriate resources).

The teachers' enthusiasm for and commitment to using Logo with their pupils rarely emerged as a result of external stimulus (e.g. extrinsic motives for joining the course, the course itself). In other words, the teachers who joined the course for extrinsic motives (e.g. social influence, career-related reasons) appeared to find little encouragement to invest time and energy for using Logo with their pupils. In contrast, those teachers who had intrinsic motives for joining the course, such as commitment to change or need for achievement, showed considerable interest in so doing. However, when for one reason or another the teachers in these latter conditions experienced frustration with the course, this led to detachment rather than on-going involvement with that course requirement.

Lack of primary teaching experience was one of the paramount barriers to implementation of Logo in the classroom. Relatively inexperienced teachers seemed to be overloaded with their usual responsibilities of teaching to be burdened to try something new with their pupils. The teachers in the middle of their careers, in contrast, appeared to be the most interested in using Logo in the classroom. Partly because they have experienced some dissatisfaction with their jobs (a kind of mid-life crisis), many of the teachers appeared to have come to a stage in which they feel motivated to look for instructional alternatives and experiment with them in the classroom.

To an extent, the teachers' enthusiasm for and commitment to using Logo with their pupils depended on the level of resources available. In all probability, the use of Logo in the classroom was constrained by the lack of appropriate resources for so doing. It is also the case, however, that when the teachers were already greatly motivated to use computers and Logo with their pupils, they would take the initiative and engage considerable efforts to make such resources available.

Factors associated with teachers' ability to reflect upon pedagogical issues

There are obvious limits in assessing the degree to which the teachers were encouraged to reflect critically upon pedagogical issues. Therefore, special caution is necessary in attempting a tentative analysis of what was needed for teachers to become reflective. Balanced with such

caution, it seems likely that both the use of Logo with their pupils and their ability to link Logo with mathematics served as catalysts for teachers' reflection. In addition, given the importance of interaction with peers for private reflection, consideration was given to the extent to which the teachers engaged in such interaction. With regard to this latter aspect, two factors seemed to be especially relevant: *pedagogical mathematical expertise* and *learning orientation*.

The success of the course in leading the teachers to reflect upon pedagogical issues seemed to be limited. In fact, in reply to the question whether their experience with the course had led them to reflect upon pedagogical matters, most of the teachers gave negative and/or elusive answers. This contrasts with suggestions provided by other authors that: (a) teachers' participation in educational change efforts may bring them to reflect upon existing practices (e.g. Olson and Eaton, 1987; Hoyles, Noss and Sutherland, 1991); and (b) that reflection is likely to be enhanced through opportunities to bring teachers interacting with other teachers namely in staff development programmes (e.g. Lortie, 1975; Fullan, 1982). One possible explanation for the difficulty with the course objective under scrutiny is that teachers are accustomed to take little more than a reactive role in responding to educational change and staff development programmes initiatives. A further explanation may be the comparatively short duration of the course.

The teachers with little experience as primary teachers, as compared to the experienced ones, were more likely to listen to their colleagues rather than participating actively in discussion. Analogously, the teachers who have participated in staff development programmes of long duration and/or curriculum development programmes were more willing to share spontaneously their ideas than the teachers without such kinds of experience. Some of the probable reasons for these trends include relative lack of confidence of the less experienced teachers in their ability to do their jobs, and the more frequent exposures to socialisation experiences of the teachers who have participated in staff development and curriculum development programmes.

The teachers' tendency to interacting with peers seemed to be associated with their own orientation to learning. Overall, the data derived from the two countries indicate that the participants with an *autonomous* orientation to learning were more self-confident and self-assured and were more satisfied with interacting with peers than those with a *conformist* orientation. However, the association was only a fragile one. Indeed, some of the participants in the former category seemed to be too self-confident and self-assured, thus often assuming a highly dominant role.

Shifts in the teachers' attitudes towards mathematics and mathematics teaching

The Logo in-service course had as its ultimate objective broadening and enriching primary teachers' attitudes towards mathematics and mathematics teaching. Within its limits, the findings reported in Chapter 6 do seem to demonstrate that the course did offer ways of influencing certain aspects of those attitudes. Attitude change was the result of complex and numerous interactions between the teachers' initial attitudes, and the dynamics of change were best understood through the analysis of individual cases. Nevertheless, the following conclusions seem appropriate.

Shifts in the teachers' attitudes towards mathematics and mathematics teaching were more likely to occur when they were already committed to change at the beginning of the course. This finding is in line with Petty and Cacioppo's (1986) model of attitude change, as well as with Rudduck's (1988) suggestion that teachers' professional development "may be most dynamic when personal commitment to change is strong" (p. 205). However, a drive mechanism to change by itself did not ensure attitude change, nor was attitude change restricted to the teachers' initially committed to change. Of the five participants who appeared to have come into the course motivated to entertain changes in their pedagogical strategies, four seemed to have been influenced in some way by it. Of the remaining twelve participants, half of them appeared to have experienced only minor forms of development.

Shifts in the teachers' attitudes towards mathematics and mathematics teaching were closely related to the sense of personal achievement they derived from the course. The teachers whose progress in learning Logo was slow tended to become disillusioned. As a consequence, they became sceptical about the message conveyed by the course. At the end of the course, either no changes had occurred in their attitudes, or shifts were noted in the unintended direction ('boomerang' effect). However, those teachers who experienced success with their own development with Logo, considered their experience with the course as valuable and became more receptive to its message. At the end of the course, some shifts could be noted in their attitudes in the intended direction.

The shifts in the participants' views about (school) mathematics were of two kinds: (1) from a relatively fixed perspective of the subject to a more dynamic and creative one; and (2) reinforcement of the logical aspect of the subject and consequent assessment that it is not easily accessible to everyone. Those teachers with a relative strong sensitivity to mathematics had relatively few problems in programming with Logo and were able to move on to use Logo to explore mathematical ideas. Accordingly, they came to regard mathematics as a less formal and

authoritative subject. The teachers with a relatively weak sensitivity to mathematics who managed to interact with the course activities and experienced some sense of achievement came to develop the same kind of view. However, they experienced some difficulties with programming with Logo, and in particular in grasping some of the more complex features of the language. Thus, the view that mathematics is a difficult subject not easily accessible to everyone was triggered.

The shifts in the participants' attitudes towards mathematics teaching were limited in scope and the one secure generalisation that could be made concerned the role of teacher -- from a role model to a facilitator (or vice-versa). This finding might have been due to the fact that only a minority of the teachers engaged in efforts to use the computer and Logo with their pupils as part of their daily activities and applied the ideas generated during the course in their classrooms. The main disincentives were: threat to ordinary performance satisfaction, interference with regular work (because of time demands) and lack of appropriate resources. Nevertheless, partly as a result of the course approach departing from a 'regulatory' role of the course tutor to a 'facilitative' one, there were some shifts in the participants' opinions about the role of the teacher in mathematics teaching. Those teachers who came to feel at ease and even enjoy the course approach shifted their opinions about this issue in the direction of the 'role model' towards the 'facilitator'. In contrast, those teachers who experienced frustration with the course approach shifted their opinions in the opposite direction.

LOOKING BACKWARD: THE RESEARCH LIMITATIONS

In this section, I will be looking backward and comment on a few shortcomings of the first and second sub-studies. In the following sections, I shall draw on the results obtained to look forward suggesting both further research to fill the gaps and some educational implications.

Limitations of the first sub-study

One of the major limitations of the first sub-study concerns the relatively poor validity and reliability of the attitude questionnaire used in the research. Three main shortcomings of this instrument can be pointed out: (1) lack of unidimensionality of the several of the attitude scales developed (as shown by the low correlations between the items); (2) limited number of items that came to be included in those attitudinal areas; and (3) poor wording of some of the items. Such an instrument could have been improved, but this would have meant much more time in trials of its successive refinements.

Another limitation is associated with the cross-country perspective of the study. For example, it should not be forgotten that the study took place in England during the first term of the 1987/88 academic year, whereas in Portugal it was carried out in the second term. Such a difference might have some influence on the results obtained. (A similar limitation is to be considered in relation to the second sub-study as well). A further shortcoming lies on the imbalance between the percentages of the returned questionnaire in England and Portugal, the former being a great deal lower than the latter. In turn, in Portugal, the fact that a considerable number of returned questionnaires were eliminated from the final analysis due to the evidence of 'contamination' must also be regarded as a major drawback. It should be stressed, however, that the two samples used for the purpose of the analysis were examined for representativeness (in terms of the variables available in official statistics) and were considered similar to the populations surveyed.

Limitations of the second sub-study

A basic limitation of the second sub-study derives from the methodology employed. In fact, this sub-study only involved a small number of teachers who volunteered to join the Logo in-service course. It is recognised, nevertheless, that there were considerable variations in the participating teachers' characteristics, namely age, years of experience, and academic and professional qualifications. It is also worth noting that the attitudes of the course participants in each country reflected to a large extent the opinions which in the light of the results of the first sub-study can be considered largely defined by country.

A further limitation of the study is related to its design. Being based on a short-term investigation, the study did not allow me to examine whether the shifts in the teachers' attitudes were lasting. Clearly, it is also open to question whether the teachers' participation in the course could have some kind of effects on their attitudes and practices in the classroom over the months after completion of the course. As one participant suggested at the final interview: "things take time to percolate ...".

Another limitation of this sub-study was that it involved a Logo in-service course conceived by myself with particular goals in mind. To the extent that the characteristics of the Logo course are considered to be an important factor in affecting the participants' interactions with the course the results of the sub-study can only be seen as trustworthy in the specific settings studied. This brings me to the next shortcoming of the study -- the short duration of the Logo in-service course. Previous studies that have attempted to effect changes in teachers' attitudes towards mathematics and mathematics teaching (e.g. Biggs, 1983; Hoyles, Noss and Sutherland, 1991) have pointed to the need for staff development programmes of considerably

longer duration. This is not easy, however, due to the formidable demands placed on teachers associated with participation in such long programmes. I was determined not to yield such pressure on teachers, but the solution I used also turned out to be considerably demanding. This was especially so for the Portuguese teachers who had no previous experience with computers. Had the course been longer, the teachers might have felt more relaxed to cope with the difficulties inherent in trying something new.

LOOKING FORWARD: FILLING THE GAPS

This study has highlighted three major issues. First, it has illustrated various aspects of teachers' attitudes towards mathematics and mathematics teaching. Second, it has made clear that cultural, social and even political factors are relevant to teachers' attitudes. Third, it has suggested that teachers' attitudes are modifiable and has sketched forms of attitude change which occurred throughout their participation in a Logo-based mathematics in-service course. The major significance of this study lies not so much in its findings, but rather in illuminating the complexity of teachers' attitudes and attempts to change them. It is clear that considerably more understanding is required of these issues. The following are some areas recommended for further research.

1. This study has suggested that the attitude questionnaire is a useful tool for cross-country studies of teachers' attitudes. There is therefore scope for extending the work which has been done in the study in order to develop more reliable and valid attitude scales.
2. This investigation has provided only limited evidence of differences in the attitudes of primary teachers in England and Portugal. It would be of value to replicate the first sub-study with representative samples of the populations of the two countries making use of a refined attitude questionnaire.
3. This study has achieved some progress in understanding the influence of several primary teachers' background variables upon their attitudes towards mathematics and mathematics teaching, but very little is known about how and to what degree these variables affect those attitudes. Re-analysis of the data of the first sub-study would help exploit the data more fully and provide a most useful exercise in the development of research hypotheses.
4. The influence of in-service training on primary teachers' attitudes towards mathematics and mathematics teaching is not fully understood yet. This study has also left largely unexamined the influence of school related variables upon primary teachers' attitudes. Do aspects of the

school's structure and atmosphere (e.g. emphasis on competition versus cooperation) influence those attitudes? In-depth studies, both naturalistic and clinical, of primary teachers can be used to explore teachers' attitudes, their academic and professional experiences, and school atmosphere, which may provide unique opportunities to probe into the mechanisms concerning the influence of these kinds of factors.

5. The contribution of personality characteristics to primary teachers' attitudes was not included in this study's conceptual framework, in part because of the difficulties associated with their assessment. Teachers with different personality characteristics may respond to social stimuli in different ways and consequently may differ in their attitudes. The topic is therefore worthwhile to address in future investigations.

6. There is a need for following-up teachers participating in in-service courses to ascertain long-term effects. Can the reactions of peers in schools, for example, overtake possible training influences noted immediately on completion of those courses? Can relevant effects of such courses only become evident over the months following the courses?

7. In an effort to integrate the second sub-study findings, I concluded by construing a model of the important factors that influenced teachers' interactions with the Logo course and affected their attitudes. Such a model is far from illustrating the complexity associated with potential changes in people's attitudes as a result of persuasive message. The validity of this model merits be investigated by future research.

LOOKING FORWARD: A CONCLUDING NOTE

It would be presumptuous to assume that this research would bring substantial progress to the educational world. But it would be a sad commentary, too, if at the end of this research I could not foresee any contributions of this study to the mathematics education community. I will mention two or three educational implications of this study.

The comparative approach used in the study clearly illuminates the drawbacks of importing or borrowing ideas and perspectives from one country to another, without first attempting them on a pilot scheme. In fact, if one contrasts the English and Portuguese teachers' interactions with the Logo course, it becomes evident that the course placed far greater demands on the latter. The course had to be the 'same' in the two countries (for methodological reasons); but this lays it open to the charge that it had an 'anglocentric' flavour, which might have made it inappropriate for the teachers in Portugal. The point here is that although some of the

differences may be caused by the distinct initiatives taken in the field of mathematics education in the two countries, they arise largely from different political, social and cultural contexts. Clearly, the different traditions and cultures of these two countries are readily translatable into teachers' attitudes towards mathematics and mathematics teaching.

There is also scope for drawing on the results of the study to claim that in-service courses for teachers can be an effective way of promoting change in mathematics education. In spite of the increase in recent years in the availability of such courses, much remains to be done. There is a clear need for a wider provision of in-service education for teachers. Funds should be made available for setting up and running in-service courses and mechanisms should be created to encourage teachers' participation in such courses. There are, however, a number of basic requirements for such initiatives (e.g. courses must be available locally; courses must include not only initial assistance but also a period of follow-up and monitoring; participation in the courses conditional on the commitment to full attendance).

Finally, an educational implication concerns the use of the computer and Logo in primary mathematics. Weighing the evidence of this research, it seems legitimate to infer that the computer and Logo can contribute to a new kind of context for the teaching and learning of mathematics. Such a contribution, however, is tempered by several constraints. One of them, which was addressed by this thesis, concerns the need for teacher education. As highlighted by this research, the development process for primary teachers to use the computer and Logo in a creative and exciting way tends to be of long duration. Moreover, teachers need to be convinced that their use has potential before they will commit themselves to the venture. To an extent, this can be compensated for by having pre-service teacher training including some form of computer-based education. Success in the establishment of initiatives to use the computer and Logo for a new kind of teaching and learning mathematics (or for any kind of educational change), however, is closely associated with government policies. There is little point in making the turtle move forward if somebody else has turned it right (or left) 180 degrees... In such a case, the words of the poet seem appropriate: *any great hope I kept is a great lie...*

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APPENDICES A:

The Research tools

APPENDIX A.1: The English version of the attitude questionnaire



University of London Institute of Education
20 Bedford Way, London WC1H 0AL Telephone 01-636 1500

Director: Professor Denis Lawton, BA, PhD

Department of Mathematics, Statistics and Computing Enquiries: Ext. 449
Chairperson: Professor Celia Hoyles
Professor Harvey Goldstein

November 1987

Dear Colleague:

The enclosed questionnaire was developed as part of a personal research project which aims at comparing the attitudes to mathematics and its teaching of English primary teachers and Portuguese primary teachers. A Portuguese version of the questionnaire will be used with primary teachers in Portugal.

The questionnaire takes 15 to 20 minutes to answer. Your participation will be very much appreciated and hopefully mutually beneficial. You are not required to write your name on the questionnaire, but you are asked to provide some details of your personal and professional background which will assist in the analysis of the data. However, your answers will remain confidential and no attempt will be made to identify individual respondents. This survey has the support of and is sponsored by the Suffolk County Council Department of Education, but the returned questionnaires will only be used for the purposes of my personal research. Please answer honestly to all the questions and give your own opinions and beliefs.

Full instructions for completing the questionnaire are provided in the "INTRODUCTION" sheet accompanying it. I would appreciate if you were able to return the completed questionnaire before the end of November. If you have any matters you wish to raise concerning this study please feel free to contact me.

Thanking you in advance for your time and cooperation,

Yours gratefully,

Cândida Moreira

(Ex-Professor of Education at Viseu Polytechnique Institute, Portugal)
(Ph.D. student at Institute of Education, London)

INTRODUCTION

This questionnaire is in three sections:

1. Attitudes to mathematics
2. Attitudes to the teaching of mathematics
3. Background information

The two former sections include several statements which represent views respectively related to mathematics and its teaching. In the second section, mathematics is obviously meant to be primary school mathematics, while in the first section mathematics has a broader meaning. Please indicate the extent of your agreement or disagreement by circling one and only one of the numbers on the 5-point scale according to the following:

- 1 = Strongly disagree
- 2 = Disagree
- 3 = Uncertain
- 4 = Agree
- 5 = Strongly agree

Please try to complete these sections as quickly as possible and try to use the "3 = Uncertain" category only if you are absolutely insecure about your inclination. Clearly, there are no right or wrong answers, nor is one kind of answer preferable to another. There are also two open-ended questions, one at the end of each of those two sections, which I would like you to answer as carefully as possible. If you wish to clarify any of your answers, please do so by writing your comments in the spaces provided.

The third section is somewhat easier to complete. It seeks information about you and your professional background, but confidentiality will be kept. Please give written responses in the spaces provided or place a tick in the appropriate box where alternative answers are given.

SECTION I: ATTITUDES TO MATHEMATICS

1. Maths was one of my best subjects when I was at school.

Strongly disagree

Strongly agree

1 2 3 4 5

2. School mathematics will change dramatically in the near future.

1 2 3 4 5

3. Mathematics is a creative subject as art or music.

1 2 3 4 5

4. I hated mathematics when I was at school.

1 2 3 4 5

5. You can only understand mathematics if you have a logical mind.

1 2 3 4 5

6. Maths is one of the most important subjects to study.

1 2 3 4 5

7. Almost anybody can learn maths if it is properly taught.

1 2 3 4 5

8. Mathematics is consistent, certain and free of ambiguities.

1 2 3 4 5

9. I enjoy talking to other people about mathematics.

1 2 3 4 5

10. I find maths confusing.

1 2 3 4 5

11. I like all aspects of mathematics.

1 2 3 4 5

12. Mathematics is the science of formal structures and rigorous logic.

Strongly disagree

1

2

3

4

Strongly agree

5

13. Only people with a very special ability can learn mathematics.

1

2

3

4

5

14. Mathematics is fun and exciting.

1

2

3

4

5

15. There is a fascination in studying maths irrespective of its usefulness.

1

2

3

4

5

16. Maths is very useful because it helps in the study of other subjects.

1

2

3

4

5

17. You can get along perfectly well in everyday life without mathematics.

1

2

3

4

5

18. Mathematics is mainly a collection of rules necessary for solving problems.

1

2

3

4

5

19. There is little need for more than very elementary mathematics in most jobs.

1

2

3

4

5

20. I feel a sense of insecurity when dealing with mathematics.

1

2

3

4

5

21. Most of the mathematics I studied at school was a waste of time.

1

2

3

4

5

SECTION II: ATTITUDES TO THE TEACHING OF MATHEMATICS

1. The main aim to teach mathematics is to enable pupils to appreciate and enjoy it for its own sake.

Strongly disagree

1

2

3

4

Strongly agree

5

2. The primary purpose of teaching mathematics is to provide a tool which can be used to meet the needs of everyday life.

1

2

3

4

5

3. The main objective of the study of mathematics is to develop reasoning skills that are necessary to solve problems.

1

2

3

4

5

4. The main reason for teaching maths is to develop a foundation upon which subsequent mathematics can be learned.

1

2

3

4

5

5. The main goal of teaching mathematics is to produce students who can perform the mathematical tasks specified in the curriculum.

1

2

3

4

5

6. In my maths lessons, I generally let pupils do whatever maths interests them.

1

2

3

4

5

7. Expecting pupils to discover mathematical ideas by themselves is unreasonable.

1

2

3

4

5

8. Computers in a maths class will take up a lot of the pupils' time, effort and imagination which they could put into something else.

1

2

3

4

5

9. Most of the time in a mathematics lesson should be spent with pupils practicing the basic mathematical skills till they master them.

1

2

3

4

5

10. In my maths lessons, pupils are used to discussing their own ideas and suggestions.

Strongly disagree

1

2

3

4

Strongly agree

5

11. Work in my maths lessons follow the textbook/workcards very closely.

1

2

3

4

5

12. I believe computers will make mathematics teaching more exciting.

1

2

3

4

5

13. Each mathematical problem generally has only one best way to get the solution.

1

2

3

4

5

14. Computers are especially useful in allowing children to practice mathematical skills.

1

2

3

4

5

15. As a rule, in my maths lessons, I encourage pupils to work in a cooperative way.

1

2

3

4

5

16. In my maths class I generally demonstrate procedures and methods for performing mathematical tasks.

1

2

3

4

5

17. With a little guidance most pupils should be able to discover most mathematical ideas for themselves.

1

2

3

4

5

18. Computers in a maths class can make it easier for pupils to work collaboratively.

1

2

3

4

5

19. I think that most pupils learn maths better by attending to teacher's explanations than by being left to make sense of things for themselves.

1

2

3

4

5

SECTION III - BACKGROUND INFORMATION

1. Age:.....
2. Sex:.....
3. What higher education qualification(s) do you have?(e.g. B.Ed., B.A., P.G.C.E., Dip. Ed.)

Qualifications	Name of the Institution	Date of Award
.....
.....
.....
.....

4. Please indicate your highest qualification in mathematics:

- ☐ O-level
☐ A-level

- ☐ other
☐ none

If other, please specify:

.....

5. How many years primary teaching experience have you had?

.....

6. Do you have any other teaching experience?

☐ yes

☐ no

If yes, please specify:

.....

7. Have you had any other particular responsibility related to teaching? (e.g. advisor teacher, teaching a subject to more than one class)

☐ yes

☐ no

If yes, please specify:

.....

8. How long have you been in your present school?

.....

9. What age group do you teach?

.....

10. How many computers do you have in your school?

.....

11. Do you regularly use computers in your maths lessons?

☐ yes

☐ no

If yes, what software do you use?

.....
.....
.....
.....
.....

12. Have you attended any in-service courses, lectures or short seminars in mathematics or on the teaching of mathematics during the past 5 years?

☐ yes

☐ no

If yes, specify:

Title	Duration	Date	Organised by
.....
.....
.....
.....
.....
.....
.....

13. Please indicate the name of your school:

.....
.....

Please check that you have not left out any questions by mistake

THANK YOU FOR YOUR HELP

APPENDIX A.2: The Portuguese version of the attitude questionnaire



University of London Institute of Education
20 Bedford Way, London WC1H 0AL Telephone 01-636 1500

Director Professor Denis Lawton, BA, PhD

Department of Mathematics, Statistics and Computing Enquiries Ext 449
Chairperson Professor Celia Hoyles
Professor Harvey Goldstein

Fevereiro 1988

Caro(a) colega:

O inquérito anexo foi desenvolvido como parte de um projecto de investigação pessoal, cujo objectivo é comparar as atitudes perante a matemática e perante o ensino da matemática, dos professores primários Portugueses e Ingleses. Uma versão Inglesa do questionário já foi utilizada com professores primários em Inglaterra.

O questionário leva cerca de 20 minutos a responder. A sua participação constituirá uma ajuda preciosa no referido estudo, o qual espero seja mutuamente benéfico. O inquérito é anónimo, e embora algumas questões se refiram a detalhes pessoais e relativos à sua vida profissional nenhuma tentativa será feita no sentido de identificar os inquiridos. Este inquérito tem a colaboração e o apoio da Direcção do Distrito Escolar de Viseu, mas os questionários devolvidos serão apenas usados no âmbito da minha investigação pessoal. Por favor responda francamente a todas as perguntas e dê as suas opiniões pessoais.

As instruções para completar o questionário são fornecidas na "INTRODUÇÃO". Ficaria muito grata se devolvesse o questionário devidamente preenchido antes do fim de Fevereiro. Se quiser esclarecer algum aspecto relacionado com o estudo citado, por favor não hesite em contactar-me através do "Department of Mathematics, Statistics and Computing, University of London Institute of Education".

Agradecendo antecipadamente o seu tempo e cooperação, apresento as mais cordiais saudações.

Cândida Moreira

(Ex-Professora Adjunta da Escola Superior de Educação de Viseu)
(Doutoranda na University of London Institute of Education)

INTRODUÇÃO

Este inquérito contém três secções:

1. Atitudes perante a matemática
2. Atitudes perante o ensino da matemática
3. Informação biográfica e profissional

As duas primeiras secções incluem várias afirmações relativas à matemática e ao ensino da matemática respectivamente. Na segunda secção, a palavra matemática refere-se obviamente à matemática dada no ensino primário, enquanto na primeira secção tem um sentido mais amplo. Por favor, indique o grau de desacordo ou acordo relativamente a essas afirmações, envolvendo com um círculo um e um só dos números da escala de 1 a 5, segundo o esquema:

- 1 = Desacordo total
- 2 = Desacordo
- 3 = Inseguro
- 4 = Acordo
- 5 = Acordo total

Por favor tente completar estas secções o mais depressa possível, e use a categoria "3 = Inseguro" apenas se se sentir absolutamente inseguro(a) quanto à sua opinião. Evidentemente, não há respostas certas ou erradas, nem uma escolha é preferível a outra.

A terceira secção é, de certa forma, mais fácil de completar. Através dela pretende-se obter informação pessoal e profissional, a qual ajudará na análise das respostas às secções precedentes. A confidencialidade é porém assegurada. Por favor, preencha os espaços em branco ou assinale com uma cruz os quadrados apropriados no caso de serem dadas respostas alternativas.

SECÇÃO I: ATITUDES PERANTE A MATEMÁTICA

1. Quando andava a estudar, a matemática era uma das minhas melhores disciplinas.

Desacordo Total

1

2

3

4

Acordo Total

5

2. A disciplina de matemática mudará rapidamente num futuro próximo.

1

2

3

4

5

3. A matemática é uma disciplina criativa como a arte ou a música.

1

2

3

4

5

4. Quando andava a estudar detestava matemática.

1

2

3

4

5

5. Sòmente quem tiver um espírito lógico é capaz de compreender a matemática.

1

2

3

4

5

6. A matemática é uma das disciplinas mais importantes.

1

2

3

4

5

7. Quase toda a gente é capaz de aprender matemática desde que seja bem ensinada.

1

2

3

4

5

8. A matemática é consistente, exacta e sem ambiguidades.

1

2

3

4

5

9. Gosto de falar de matemática com outras pessoas.

1

2

3

4

5

10. Acho a matemática confusa.

1

2

3

4

5

11. Gosto de todos os aspectos da matemática.

1

2

3

4

5

12. A matemática é a ciência das estruturas formais e da lógica rigorosa.

Desacordo Total

1

2

3

4

Acordo Total

5

13. Somente pessoas com habilidade especial são capazes de aprender matemática.

1

2

3

4

5

14. A matemática é uma disciplina interessante e excitante.

1

2

3

4

5

15. Há um fascínio em estudar matemática independentemente da sua utilidade.

1

2

3

4

5

16. A matemática tem grande utilidade como instrumento auxiliar no estudo de outras disciplinas.

1

2

3

4

5

17. Poucas situações da vida diária exigem conhecimentos de matemática.

1

2

3

4

5

18. A matemática é essencialmente um conjunto de regras necessárias para resolver problemas.

1

2

3

4

5

19. A maioria dos empregos exige apenas conhecimentos de matemática elementar.

1

2

3

4

5

20. Sempre que tenho de lidar com a matemática tenho uma sensação de insegurança.

1

2

3

4

5

21. A maior parte dos assuntos de matemática, que foram tratados quando eu andava a estudar, foi uma perda de tempo.

1

2

3

4

5

SECÇÃO II: ATITUDES PERANTE O ENSINO DA MATEMÁTICA

1. O principal objectivo do ensino da matemática é levar os alunos a apreciarem e a gostarem dela pelo seu proprio valor intrínseco.

Desacordo Total

1

2

3

4

Acordo Total

5

2. O propósito primordial do ensino da matemática é fornecer aos alunos uma ferramenta que pode ser utilizada nas situações da vida diária.

1

2

3

4

5

3. O principal objectivo para estudar matemática é desenvolver a capacidade de raciocínio necessária para resolver problemas.

1

2

3

4

5

4. A principal razão para ensinar matemática é desenvolver nos alunos uma base sobre a qual os conceitos mais avançados podem ser alicerçados.

1

2

3

4

5

5. O principal objectivo do ensino da matemática é conseguir que os alunos dominem os assuntos especificados no programa.

1

2

3

4

5

6. Na minha aula de matemática, normalmente deixo os alunos envolverem-se nas actividades matemáticas que mais lhes interessam.

1

2

3

4

5

7. Nao é razoável pensar-se que os alunos conseguem descobrir ideias matemáticas por eles mesmos.

1

2

3

4

5

8. Os computadores na aula de matemática tomarão muito do tempo, esforço e imaginação dos alunos que poderiam ser gastos noutra coisa qualquer.

1

2

3

4

5

9. A maior parte do tempo na aula de matemática deve ser passado com os alunos a praticarem os cálculos e técnicas básicas até os dominarem.

1

2

3

4

5

10. Na minha aula de matemática os alunos costumam debater entre eles as suas próprias ideias e sugestões.

Desacordo Total

1

2

3

4

Acordo Total

5

11. Na minha aula de matemática sigo de muito perto o livro de texto/exercícios adotado.

1

2

3

4

5

12. Acredito que os computadores tornarão o ensino da matemática mais excitante.

1

2

3

4

5

13. Geralmente em matemática, cada problema tem uma melhor maneira de ser resolvido.

1

2

3

4

5

14. Os computadores são especialmente úteis para as crianças praticarem técnicas matemáticas.

1

2

3

4

5

15. Na minha aula de matemática, geralmente encorajo os alunos a trabalhar cooperativamente.

1

2

3

4

5

16. Na minha aula de matemática costumo exemplificar os procedimentos e métodos para executar as tarefas matemáticas.

1

2

3

4

5

17. Com alguma ajuda, a maioria dos alunos deve ser capaz de descobrir a maior parte das ideias matemáticas.

1

2

3

4

5

18. Nas aulas de matemática, os computadores facilitarão a colaboração entre os alunos.

1

2

3

4

5

19. Penso que os alunos aprendem melhor matemática se prestarem atenção às minhas explicações do que se forem deixados sôzinhos a tentar compreender as coisas por eles próprios.

1

2

3

4

5

SECÇÃO III - INFORMAÇÃO BIOGRÁFICA E PROFISSIONAL

1. Idade:.....
2. Sexo:.....
3. Qual o tipo de habilitação académica pós-secundária que possui? (ex: Magist. Prim. (2/3anos), ESE)

Curso	Nome da Instituição	Data do diploma
.....
.....
.....

4. Qual é a habilitação mais elevada (aprovação) que possui em matemática?

- ☐ Ciclo preparatório ou equivalente
☐ 9º ano unificado ou equivalente
☐ Curso complementar do ensino secundário ou equivalente
☐ 12º ano
☐ Outra

Se outra, qual?

.....

.....

5. Quantos anos de serviço tem como professor primário?

.....

6. Tem alguma outra experiência docente?

☐ Sim

☐ Não

Se sim, qual?

.....

.....

.....

7. Desempenha ou já desempenhou outro tipo de funções relacionadas com o ensino?

☐ Sim

☐ Não

Se sim, qual?

.....

.....

8. Há quantos tempo exerce funções na sua escola actual?

.....

9. Indique o(s) ano(s) e fase(s) que ensina presentemente:

.....

.....

.....

10. Tem algum computador na sua escola?

☐ Sim

☐ Não

Se sim, quantos?

.....

11. No caso de ter algum computador na sua escola, usa-o com regularidade na suas aulas de matemática?

☐ Sim

☐ Não

Se sim, que programas usa?

.....

.....

.....

12. Assistiu ou participou em acção(ões) de formação contínua, curso(s), conferência(s) ou seminário(s) no domínio da matemática ou do ensino da matemática nos últimos 5 anos?

☐ Sim

☐ Não

Se sim, indique:

Título	Duração	Data	Organizado por
.....
.....
.....
.....
.....
.....

13. Identificação da sua escola:

.....

.....

Por favor verifique se não deixou, por engano, alguma questão por responder

MUITO OBRIGADA PELA SUA COLABORAÇÃO

APPENDIX A.3: The English version of the pre-interview protocol

1.BACKGROUND INFORMATION

- a)How many years have you been teaching?(Primary? Secondary?)
- b)What age group do you teach?(Have you taught other age groups?)
- c) What are your academic qualifications? (BEd, University degree, Main subject(s))
- d)How did you come to choose this subject? (Which alternative subjects would you prefer to have chosen?)
- e)What are your highest qualifications in mathematics?
- f)What kind of training did you have, if any, to teach mathematics? (What do you think about it? Useful? Appropriate?)
- g)Would you like to think back to the time you decided to become a primary teacher and tell me how did you happen to decide to do so?

2.ATTITUDES TOWARDS COMPUTERS

- a)Have you used computers? (In what connection?)
- b) What do you feel about computers in general in society?
 - b1)What are the advantages and disadvantages you see in its use?
- c)What do you think about the role of computer in education?
 - c1)What are the advantages and disadvantages you see in its use?
 - c2)In what curriculum areas do you consider that computers can be used?
- d)What do you think about the role of the computer in mathematics education? (in terms of pupil's learning, mathematical content, role of the teacher)
- f)What problems do you anticipate about using the computer in your maths lessons (management, time constraints, syllabuses constraints)

3.ATTITUDES TOWARDS MATHEMATICS

- a)How do you feel about mathematics as a subject? (In terms of like/dislike, usefulness, difficulty, self confidence)
- b)What were your attitudes towards mathematics in school? (Primary, secondary, university or college level)
- c)What kind of factors have influenced your attitudes towards mathematics?
- d)Once more I would like you to think back to the past. Can you describe me a time when you feel particularly good or particularly bad when dealing with mathematics. (Be as specific as possible)
- e) This might be a difficult question. Anyway I would like you to try to answer it. If you have to explain to somebody what mathematics is about what would you say?

4. ATTITUDES TOWARDS THE TEACHING OF MATHEMATICS

- a) What are in your opinion the reasons to teach maths in primary school?
- b) What kind of teaching aids do you use in your maths lessons?
 - b1) Books.
 - b2) Structured apparatus.
 - b3) Other materials.
- c) Approximately which percentage of the week time do you spend with maths lessons? (Everyday? More or less time than devoted to other curriculum areas?)
- d) I would like you to describe the way you've organised the maths lesson today. What activities did you use? (Teacher exposition, discussion between teacher and pupils, discussion between pupils, practical work, consolidation of practice of fundamental skills, problem solving, mathematics for everyday life, investigations)
 - d1) Comparing with other maths lessons would you say that was similar or different?
 - d2) How do you introduce a new concept?
- e) How do you evaluate the work and progress of your pupils?

5. PUPILS

- a) How would you describe the attitudes of most of your pupils towards maths?
- b) What is the level of ability of your pupils in maths?
- c) How do you compare the difficulties pupils have in maths and in other subject areas?

6. INVOLVEMENT IN THE PROJECT

- a) There might be several reasons to come to an inset course. In the present case, what were the reasons for joining this course? (Are you taking this course out of personal interests, do you see it as helping you in your future career?)
- b) What do you expect to get out from the course?

CONCLUSION

- a) The interview is virtually over. I think I have covered most of the issues I was interested in. Are there any other matters you would like to raise related to the issues we've been talking about?
- b) Anything else?

APPENDIX A.4: The English version of the post-interview protocol

INTRODUCTION

Thank you so much to accept to take part in this interview. I hope you don't mind I use the tape recorder to keep a record of our chat. I would like to assure you that your comments will be treated as strictly confidential. As you know the Logo course you attended was part of a my personal research which aims at comparing the impact of a Logo course on English and Portuguese primary teachers.

I am interested in hearing your honest opinions and beliefs, so please answer accordingly, even if you think your comments are not altogether favourable. Positive and negative comments are very well welcome and certainly will help me in my main study. I will ask you about the course itself; also I'd like to explore your views on computers, mathematics, and the teaching of mathematics. Some of the questions I've asked before in the previous interview. I'd like to see now whether your views have changed at all since finished the course. Any questions before we start?

COURSE EVALUATION

a) I would like you to think retrospectively and tell me how did you feel throughout the course. I also would like you to describe things or situations that stood out for you.

a1) Were you thinking of a specific incident, or does any example comes to your mind?

a2) Anything else which had stood out for you throughout the course?

ATTITUDES TOWARDS COMPUTERS

a) What do you feel about computers?

a1) In general in society?

a2) In education?

b) In asking about the role of the computer in maths education during the interviews which were carried out before the course starts, I got a variety of interesting answers. Here are four of them:

1) "An opportunity to use problem solving skills"

2) "A very good tool for reinforcing what the children have been learning"

3) "A tool to explore aspects of maths, to question and to find out"

4) "A means to teach new concepts"

b1) Which of these four answers is closer to your own opinion now?

ATTITUDES TOWARDS MATHEMATICS

a) The course title was "Teaching and Learning Maths with log in Primary school". You've told me what maths you can teach with Logo. Now, I would like to ask you tell me what maths, if any, you have learned.

b) If you have to explain to somebody what mathematics is about what would you say?

c) In what ways has your experience with the course has effected your own attitudes towards mathematics (confidence, liking, usefulness, links with other subjects)

ATTITUDES TOWARDS THE TEACHING OF MATHEMATICS

a) The implementation of Logo in your classroom naturally led you to reflect on the ways of doing so. To what extent this experience led you to reflect on the teaching of maths. In what ways, if any, have you been influenced by the course? (e.g. willingness to try new ideas and approaches in teaching mathematics; belief that you can effect changes in maths education)

b) In what ways the fact of being in a course in a student's position led you to reflect on the role of the teacher and learner in maths lessons?

c) In the previous interviews I asked you about the way you organise your maths lessons and what kinds of activities do you normally use in them. Now, I would like to be more specific and ask you to describe the way you organised today your maths lessons.

a1) Is this typical now? How about other lessons this week?

d) In the interviews I carried out before the course started, I asked about reasons for teaching mathematics in primary school and I got several answers which can be expressed by the following statements:

1) "To make children realise that maths is a subject that can be enjoyed"

2) "To obtain the skills children need in society"

3) "To allow children to think in a more abstract way"

4) "To be able to look for patterns and relationships"

5) "To provide a basic grounding in numeracy for further mathematics and other subjects"

Would you please rank order from 1 (your first priority reason) to 5 (that reason you think least important)

CLASSROOM OUTCOMES

a) How did you feel about implementing Logo with children?

b) What kind of Logo work have you tried with your pupils?

b1) Off-computer activities? On-computer activities?

b2) How often have you used Logo?

b3) What sort of activities has Logo replaced?

b4) How have you had organised the Logo work?

c) What were your pupils' reactions in working with Logo?

c1) What percentage of pupils has shown interest in Logo?

c2) Have you noticed any differences in pupils' reactions? (Boys and girls, bright and less able children, pupils with and without previous computer experience)

e) What are the mathematical ideas and concepts that you think can be explored by using Logo?

e1) What do you see as being advantages and disadvantages of using Logo to explore those ideas

f) What other possible positive and negative outcomes can result from children working with Logo

g) What were your major obstacles and successes on implementing logo with your pupils?

CONCLUSION

a) To which extent were your initial expectations about the course fulfilled?

b) May I ask what are you likely to do with Logo in the future?

c) You can see the lines on which I've explored the value of the course for you. Are there any other ways in which the course has influenced you; either positive or negative comments are welcome.

d) Any further comments?

APPENDICES B:

Data analysis efforts and methods

APPENDIX B.1: List of variables and coding for the English questionnaire

Variables brief description

<u>VARIABLE</u>	<u>COLUMN</u>	<u>NAME</u>
1	1-3	Identification number of the questionnaire
2	4-6	Identification number of the school
3	7	Data of questionnaire reception
4	8	Type of school
5	9	Geographical situation
6	10-12	Number of pupils in the school
7	13-14	Number of teachers in the school
8	15-16	Age of respondent
9	17	Sex of respondent
10	18	Academic qualifications
11	19	Initial academic type of qualification
12	20-21	Data of award
13	22	Further type of qualification
14	23-24	Data of award
15	25	Highest qualification in maths
16	26	Highest qualification in maths (Other cat)
17	27-28	Number years primary teaching
18	29	Other teaching experience (Y/N)
19	30	Type of other teaching experience
20	31	Responsability related to teaching (Y/N)
21	32	Type of responsibility
22	33-34	Number years in the present school
23	35	Age group
24	36	Number of computers in school
25	37	Use regular of computers in maths (Y/N)
26	38	Type of software used in maths
27	39	Attendance to in-service courses (Y/N)
28	40	Number of courses attended
29-49	41-61	Atm1 to Atm21
50-68	62-80	Attm1 to Attm19

Variables detailed description

<u>VARIABLE</u>	<u>COLUMN</u>	<u>DESCRIPTION</u>
1	1-3	Identification number of the questionnaire. Range 1-900.
2	4-6	Identification number of the school. Range 1-309. No answer = 999.
3	7	Data of questionnaire reception. 1=15 Nov to 4 Dez 2=7 Dez to 24 Dez 3=28 Dez to 15 Jan 4=18 Jan to 5 Fev 9=Not known
4	8	Type of the school 1=5 to 11 2=5 to 7 3=7 to 11 4=7 to 10 5=5 to 9 or 5 to 10 6=9 to 13 or 10 to 13 9=If school not known.
5	9	Geographical situation. 1=Urban. 2=Rural. 9= If school not known.
6	10-12	Number of pupils. Code actual number. If school not known=999.
7	13-14	Number of teachers. Code actual number. If school not known=99.
8	15-16	Age of respondent. Code actual age in years. No answer= 99.
9	17	Sex of respondent. 1=Masculin. 2=Feminin. 9=No answer.
10	18	Higher qualifications. 1=Initial academic qualification only. 2=Initial academic qualification + further academic qualification. 3=None. 9=No answer

11	19	Type of initial academic qualifications 1=Dip.Ed. or Teach Cert or Cert.Ed 2=BA or BSc or Univ Degree + PGCE or Cert.Ed. 3=BA or BSc 4=MA 5=Advanced Dip.Ed 6=BEd 0=Other or not specified 8=Not applicable.
12	20-21	Data of award. Code actual data (decade). Not applicable = 98. No answer = 99.
13	22	Further academic qualifications. 1=Dip.Ed. 2=BEd 3=MA or MSc or Research degree. 4=Advanced Dip.Ed. 5=BA or BSc 0=Other or not specified. 8=Not applicable.
14	23-24	Data of award. Code actual data (decade). Not applicable = 98. No answer = 99.
15	25	Highest qualification in maths. 1=O-level. 2=A-level. 3=CSE. 4=None. 0=Other. 9=No answer
16	26	Highest qualification in maths (other cat). 1=Dipl.in Maths.or BEd with maths as main subject 2=BSc. or BA in maths 3=MSc. or MA 4=Non award bearing Maths course. 5=Basic maths course at College 0=Other. 8=Not applicable. 9=No answer.
17	27-28	Number years primary experience (including middle school). Code actual number (by default). 99=No answer.

18	29	Other teaching experience. 1=Yes. 2=No. 9=No answer
19	30	Type of other teaching experience. 1=Nursery. 2=Secondary. 3=FE. 4=Teach.Training. 0=Other. 8=Not applicable. 9=No answer
20	31	Responsability related to teaching. 1=Yes. 2=No. 9=No answer.
21	32	Type of responsibility. 1=Head teacher. 2=Deputy Head. 3=Responsibility with maths. 4=Responsibility with Computers. 5=Head teacher or Deputy head with responsibility with maths. 6=Responsibility with maths and computers. 0=Other kind of responsibility. 8=Not applicable. 9=No answer
22	33-34	Number years in the present school. Code actual number (by default). 99=No answer
23	35	Age group. 0=Reception or 4-6 or 3-7 or 5 1=5-7 or 6-7 or 5-6 or 6. 2=6-8 or 7-8 or 7 . 3=7-9 or 8-9 or 8. 4=8-10 or 9-10 or 9. 5=9-11 or 10-11 or 10 or 11. 6=all type of school age group. 7=5-9 or 6-9 or 6-10. 8=7-10 or 7-11 or 8-11. 9=No answer.
24	36	Number of computers in school. 1=one computer. 2= two computers. 3= Three computers. 4=Four computers. 5=Between five and ten computers. 6=Ten or more computers. 9=No answer

25	37	Use regular of computers in maths. 1=Yes. 2=No. 8=Not applicable. 9=No answer.
26	38	Type of software used. 1=Logo or Logo + others (except SMILE and Northants). 2=SMILE or SMILE + others (except Logo and Northants). 3=Northants or Northants + others (except Logo and SMILE) 4=Logo + SMILE or Logo + SMILE + others (except Northants) 5=Logo + Northants or Logo + Northants (except SMILE) 6=SMILE + Northants or SMILE + Northants + others (except Logo) 7=Logo + SMILE + Northants or Logo + SMILE + Northants + others 0=Others or no especificied. 8=Not applicable. 9=No answer.
27	39	Attendance to in-service courses. 1=Yes. 2=No .9=No answer.
28	40	Number of in-service courses attended. 1=One. 2=Two. 3=Three. 4=Four 5=Five or more. 6=Various no especificied. 7=Attendance to at least one long course. 9=No answer.
29-49	41-61	Atm1 to Atm21 1=Strongly disagree 2=Disagree 3=Uncertain 4=Agree 5=Strongly agree 8=Circle two numbers or modify the content of question. 9=No answer
50-68	62-80	Attm1 to Attm19 1=Strongly disagree 2=Disagree 3=Uncertain 4=Agree 5=Strongly agree 8=Circle two numbers or modify the content of question. 9=No answer

APPENDIX B.2: Regression analysis considerations

The explanatory variables

The nine explanatory variables that were considered for the several regression analysis undertaken are given in the following figure:

Level I	Level II	Level III
X1: Age X2: Sex	X3: Highest mathematics qualifications X4: Initial academic qualifications X5: Other teaching Experience X6: Length of primary teaching experience X7: Posts of responsibility related to teaching	X8: Attendance at in-service courses in mathematics education X9: Use of computers in maths lessons

In this figure, there are three levels of variables. The variables in Level I are those upon which there is no control -- *teachers' biographical characteristics*. While there may be interesting relations between these variables and the dependent variables, I was primarily concerned with the effects of the variables of levels II and III. Level II consists of *teachers' academic and professional experiences*, each of which is thought to have some influence on their attitudes towards mathematics and mathematics teaching. The variables of level III are the most pertinent in this research -- *teachers' 'special' professional experiences*.

Recoding the explanatory variables into binary form

Regression analysis can only be performed when the independent variables are either continuous or dichotomous. For categorical independent variables, it is necessary first to recode them into dichotomous linearly independent variables. From the methods available to do so, I used that known as *dummy coding* (Pedhazur, 1982¹). This generates for each variable with k categories a set of k-1 dichotomous variables, each of them being assigned the values 1 or 0 corresponding to membership or not membership in a given category. The procedure is illustrated for the variable *highest mathematics qualifications* (X3). Four categories had been assigned to the variable: 1 - *no specific qualifications (including non-response)*; 2 - *O-level or equivalent*; 3 - *A-level or equivalent*; 4 - *qualifications at College or University level*. So from this variable three new variables, labelled X31, X32, X33, were specified as follows:

X31	1 if X3 = 1, otherwise 0
X32	1 if X3 = 2, otherwise 0
X33	1 if X3 = 3, otherwise 0

Selecting the explanatory variables

Another important point is that there is usually limited usefulness to adding variables to a regression equation if these bear no relationship with the criterion variable. Hence, for each of the attitudinal scales, the independent variables actually entered in the regression equation were those (from the nine background variables under consideration) which were found to contribute to the variance of the attitudinal scores when they stood alone.

In an attempt to examine the relative importance of each of the nine independent variables to each of the dependent variables, simple regression (in the case of the continuous independent variables) and multiple regression (in the case of categorical independent variables) analyses were performed. The amount of variance of the scores on the six attitudinal scales accounted

¹ Pedhazur, E. (1982). *Multiple regression in behavioral research*. New York: Holt, Rinehart and Winston.

for by each of the independent variables are of interest in themselves and are shown in Table B.2.1.

Table B.2.1: Variance in the summary scores corresponding to six attitudinal scales accounted for by the selected independent variables when they stood alone**

	Nature of mathematics	Mathematics as a subject	Mathematics and oneself	Nature of learning mathematics	The teaching milieu	Computers in mathematics
<i>Level I</i>						
X1	.050	.009	.000*	.012	.017	.001*
X2	.001*	.006*	.029	.000*	.001*	.003*
<i>Level II</i>						
X3	.009*	.017	.151	.018	.002*	.008*
X4	.023	.023	.004*	.022	.030	.013*
X5	.004*	.000*	.001*	.003*	.001*	.018
X6	.045	.007*	.006*	.017	.018	.001*
X7	.003*	.060	.103	.019	.028	.014
<i>Level III</i>						
X8	.014*	.059	.039	.068	.071	.023
X9	.009	.026	.008*	.019	.016	.102

* Not statistical significant at 0.05 level;

** X1: Age; X2: Sex; X3: Highest mathematics qualifications; X4: Initial academic qualifications; X5: Other teaching experience; X6: Length of primary teaching experience; X7: Posts of responsibility related to teaching; X8: Attendance at in-service courses in mathematics education; X9: Use of computers in maths lessons.

Specifying two regression models

Another issue that was necessary to resolve in order to proceed with the regression analysis method was that of deciding in which order the independent variables should be entered in the different regression equations. The problem emerges because in non-experimental research the independent variables are most likely to be correlated. For that reason, the contribution of an independent variable to the variation of the dependent variable is dependent of the presence of other independent variables which are already in the equation. Of the innumerable possible ways of entering the independent variables in the regression equation I finally decided to use two different models. By using two distinct models, I hoped that I would increase the understanding of existing relationships between dependent and independent variables.

In the first one (Model 1), I opted for fitting a general model for all the dependent variables based on theoretical considerations which postulates the order in which the independent variables should be entered. The enter order is given by variables indices. The rationale for this order is given next.

First, it was felt that the model should emphasise the explanatory power of the two most pertinent variables within the present research (attendance to in-service courses in mathematics education and use of computers in mathematics lessons). This was thought to be better illustrated if these variables were entered after all the other independent variables, that is after the effects of all other variables had been controlled. Within each level, the criteria used to decide on the entry order of each variable were the following: (a) if an assumed relationship existed between two variables then the variable to be entered first was that influencing a variable to be entered subsequently; (b) if no assumed relationship existed between two variables or if they were mutually influential, then the variable to be entered first was that considered to have a more efficient explanatory value. For example, the variable teacher's type of responsibility related to teaching may be considered as dependent on the variable teacher's type of academic qualifications and length of teaching experience. Therefore the latter two variables should be entered before the first one. Also, age should be entered before sex given that the existing literature has suggested that age is a relatively more important factor than sex when considering teachers' pedagogical strategies.

The second model (Model 2) was based upon a procedure commonly used in regression analysis (the *stepwise selection* of independent variables). The *stepwise* method consists of selecting first the variable which has the highest correlation with the dependent variable. The remaining variables are selected successively in order to achieve the maximum increase of variation of the dependent variable that can be accounted to the entered variable in conjunction with those variables already in the equation. Although attractive, this procedure, as it stands, was not suitable for the present analysis because the presence of several *dummy* variables (see next sub-section) would make it difficult to interpret the contribution of the independent variables initially considered. An alternative solution was to consider for each dependent variable the entry order of the explanatory variables in the regression equation that was suggested by the amount of variation accounted for by each of the independent variables when they stood alone. That is, the first variable to be entered in the equation was that whose contribution to the variance of a given dependent variable had been found to be the highest. The next variable to be entered in the equation was the one corresponding to the second highest contribution, and so forth.

An illustrative example: Accounting for the variation in teachers' personal feelings towards mathematics

With so many dependent and independent variables, it would be unrealistic to describe here all the analyses undertaken and the results of those analysis. To simplify matters, I report only with some detail the analyses undertaken and the results associated with the *Mathematics and Oneself* scale. The choice of this scale resides in that it is that corresponding to the higher variance accounted for by the selected variables (26%).

The independent variables chosen on the basis of their contributions to the score on the *Mathematics and oneself* scale when they stood alone (See Table B.2.1) are: *Sex* (X2), *Highest academic qualifications* (X3), *Posts of responsibility related to teaching* (X7), and *Attendance at in-service courses in mathematics education* (X8). In the regression equation corresponding to Model 1, the variables were entered as they were designated. Thus, the first variable to be entered in the equation was X1. The next variable to be entered would be X3. Since X3 is a categorical variable, the variables to be entered at a time were the dummy variables associated with it (X31, X32, X33). The next variables to be entered were the dummy variables associated with X7, and so forth. Table B.2.2 displays the summary statistics for the regression equation.

Table B.2.2: Summary statistics for the regression equation corresponding to the *Mathematics and oneself* scale summary scores (Model 1)

Step	Variables	Raw Weights (B)	Standard Error of B (SE B)	Multiple R	Multiple R Squared	Change in R Squared	F- ratio	Signif. F
1	X1**	0.47	0.37	0.17	0.03	0.03	13.05	0.00
2	X32	-0.57	0.48	0.40	0.16	0.13	22.16	0.00
	X33	2.08	0.75					
	X31	-3.57	0.65					
3	X71	1.03	0.37	0.49	0.24	0.08	13.50	0.00
	X72	1.59	0.63					
	X73	2.80	0.49					
4	X82	-0.60	0.80	0.51	0.26	0.02	2.30	0.06*
	X83	-0.25	0.80					
	X84	0.38	0.79					
	X81	-0.89	0.78					
	(Constant)	12.96	1.03					

* Not statistical significant at 0.05 level

** X1: Age; X31, X32, X33: dunmmy variables associated with *Highest mathematics qualifications*; X71,X72, X73: dunmmy variables associated with *Posts of responsibility related to teaching*; X81, X82, X83, X84: dunmmy variables associated with *Attendance at in-service courses in mathematics education*.

In Table B.2.2, columns five to nine provide the statistics that are obtained at the end of each step. Of special importance are the proportions of variance accounted for by an independent variable (or set of associated *dummy* variables) that is added to the equation (seventh column), as well as whether or not this contribution is statistically significant (extreme right column). The raw weights (B) gotten when all the variables are entered (third column) constitute the coefficients of the regression equation. The standard errors of these coefficients (SE) give an estimate of the reliability of these coefficients.

The equation that relates the predicted scores (Y) on the *Mathematics and oneself* scale with the independent variables is:

$$Y = 12.96 + 0.47 (X1) - 0.57 (X32) + 2.08 (X33) - 3.57 (X31) + 1.03 (X71) + 1.59 (X72) + 2.80 (X73) - 0.60 (X82) - 0.25 (X83) + 0.38 (X84) - 0.89 (X81)$$

The summary statistics displayed above and the multiple regression equation associated with them suggest several findings. The variable *Highest qualifications in mathematics* appears to be the best predictor of the *Mathematics and oneself* attitudinal scores. The relationship between the two variables is the expected one. Other variables kept constant, the teachers who have no qualifications in mathematics (corresponding to having the value 1 assigned to the variable X31) have the lowest scores in the scale. In turn, those teachers who reported to have an A-level or equivalent in mathematics (corresponding to having the value 1 assigned to the variable X33) are those who have the higher scores on the scale. Note in passing that nothing can be said concerning the teachers who have reported to have an O-level or equivalent (corresponding to having the value 1 assigned to the variable X32), since the standard error of the regression coefficient of X32 is considerably high (0.48) when compared with the absolute value of the regression coefficient (0.57).

Significant differences between mean scores are also found in the subgroups of teachers formed taking into account their type of responsibility within the school system. For example, those teachers who have been responsible for mathematics and/or computers (corresponding to having the value 1 assigned to the variable X73) have higher than the other groups since the regression coefficient of X73 is considerably higher than the coefficients of X71 and X72. Sex (X1) also appears to be related to the teachers' feelings towards mathematics. As can be seen, male teachers' scores are higher than their female counterparts (male teachers are coded 1 and female ones are coded 0). The influence of this variable (*sex*), however, seems to be less striking than the two previous ones. Indeed, the standard error of the regression coefficient associated with this variable (0.37) is considerably high when compared with the coefficient, thus suggesting that the coefficient is unreliable and should be interpreted with special caution.

Finally, the lack of statistical significance (F-ratio of 2.30 which is not significant at 0.05 level) of the increment added to the variance of the *Mathematics and oneself* scale scores by the dummy variables associated with the *attendance at in-service in mathematics education* suggests that this variable accounts little for explaining the variability of those scores when the other variables have been already taken into consideration.

It may be worth displaying the summary statistics yielded by the regression analysis when the variables are entered according to the order suggested by Model 2 (see Table B.2.3). From Table B.2.3, it can be seen that the proportions of the variances of the dependent variable accounted for by the different independent variable are in general different from the previous ones. (Of course, the raw weights (B) and that the standard errors of the raw weights (SE) are the same). Note, in particular, that now the proportion of the variance accounted for by the variable X1 (*Sex*) is not statistically significant. That is, this variable seems to be relatively unimportant as compared to *Highest qualifications in mathematics* and *Posts of responsibility related to teaching* in predicting teachers' feelings towards mathematics (as measured by the *Mathematics and oneself* scale).

Table B.2.3: Summary statistics for the regression equation corresponding to the Mathematics and oneself scale summary scores (Model 2)

Step	Variables	Raw Weights (B)	Standard Error of B (SE B)	Multiple R	Multiple R Squared	Change in R Squared	F- ratio	Signif. F
1	X33**	2.08	0.75	0.39	0.15	0.15	25.00	0.00
	X31	-3.57	0.65					
	X32	-0.57	0.48					
2	X72	1.59	0.63	0.48	0.23	0.08	14.71	0.00
	X73	2.80	0.49					
	X71	1.03	0.37					
3	X82	-0.60	0.80	0.50	0.25	0.02	2.30	0.06*
	X83	-0.25	0.80					
	X84	0.38	0.79					
	X81	-0.89	0.78					
4	X1	0.47	0.37	0.51	0.26	0.01	1.43	0.23*
	(Constant)	12.96	1.03					

* Not statistical significant at 0.05 level.

** X1: Age; X31, X32, X33: dunmmy variables associated with *Highest mathematics qualifications*; X71,X72, X73: dunmmy variables associated with *Posts of responsibility related to teaching*; X81, X82, X83, X84: dunmmy variables associated with *Attendance at in-service courses in mathematics education*.

APPENDIX B.3: Example of the pre-interview summary sheets

ATTITUDES TOWARDS COMPUTERS			
PERSONAL FEELINGS	ADVANTAGES & DISADVANT.	COMPUTERS IN TEACHING	COMPUTERS IN MARKS
<ul style="list-style-type: none"> I feel fascinated by computers I've always seen it perhaps more favourably than some other people Very exciting things I look at comp very positively 	<ul style="list-style-type: none"> Very powerful tools of communication We forget how to write The art of conversation may well go I hope that it won't take over and completely destroy the skills that we have like writing / talking Many applications for computer shopping 	<ul style="list-style-type: none"> Comp. could be used for what are more than just a rather expensive word and a skills practice thing Word processing an exciting method and very stimulating for children I think that is important that ch know what comp can or cannot do, if you don't tell it something it can't do anything The role of comp is to support the curriculum rather than be an end of itself We expect to have at least one comp in every classroom, to enable it to use it as often as they want Spelling enough machines do ch get very little work on One of the big advantages was particularly with less able ch. for whom writing is a problem Advantages outweigh any disadvantages 	<ul style="list-style-type: none"> To support the curriculum To offer things to and present things in an exciting way
Not applicable	Not applicable	Not applicable	Response part with to all parts about comp in marks

JOHN

PLF

ATTITUDES TOWARDS MATHEMATICS

PAST MATHEMATICS	CRITICAL INCIDENTS	VIEWS OF MATHEMATICS	OTHER
<ul style="list-style-type: none"> In primary, I did find maths difficult. When it came to applying it to problems I could never work out whether it was adding or subtracting. In secondary, suddenly it was, well, better. I think it was because the teachers were all skilled and it became awfully clear. I did applied and pure maths at A level anyway. I didn't love it. I didn't do any questions, rather than I had a failure to understand. I didn't find it terribly easy. Formulae and working things out I used to enjoy. Once I got the idea and it was put rather like crossword puzzles. It was a series of mental ability. 	<ul style="list-style-type: none"> It was at an interview to my secondary school I was taken off to do a test including a maths problem. There was an odd happening that I missed. I remember the generosity of the teacher who was talking next to me, in helping me get the right answer. As for a bad experience I think doing problems at primary school. I used to hate problems. All of them, as soon as it was a problem and on some on the words were "How instead of a". Not applicable. 	<ul style="list-style-type: none"> The answers are important in maths. You don't have to actually make the last statement in an A level question, but it is it is necessary to be able to get the right answer ultimately. Maths is about numbers. It is a type of language. An easy language once you get to know the rules. It helps you solve problems and there are applications to things. Maths is a good way of applying it in its own right. I think perhaps you do need to be quite capable, clever to do very well in it, a particular kind of mind. Responds positively to all questions about school maths. Considers maths as many a use of a series of rules. Expresses views that maths is consistent, and the release of formal thinking. Is sceptical whether it is not you need a logical mind to understand maths. 	<ul style="list-style-type: none"> Responds positively to all questions about enjoyment of and confidence with maths.

JOHN





PRE

ATTITUDES TOWARD THE TEACHING OF MATHEMATICS

PERSONAL FEELINGS	AIMS OF TEACHING MATH	NATURE OF LEARNING	CLASSROOM CONTEXT
<ul style="list-style-type: none"> It's probably the thing I least want I think I enjoy teaching maths Whether children enjoy or teaching math is another question The ability of not and put through away from it or put into the classroom to me, the boundaries are almost 	<ul style="list-style-type: none"> To have a numerical population It's something that can be put into it as a reason or way to teaching it It does have very relevant applications to future careers Teaching basic principles and the ability to be able to put many sets is very important. 	<ul style="list-style-type: none"> The challenge in teaching is to find the different way of looking at the problem and not think that there's only one way of doing it It's a challenge trying to work out how best to put a concept in the process. There is much more emphasis on abstract observations rather than concrete ones which is a weakness because you can't expect even children to be able to do complicated calculations. Could it be in a more maths are perhaps more personal than many other subjects. I've always tried to teach a child adding up the way she understands it. Her understanding may not be the same for all the children in the process. I think I saw the individual child but on an individual basis. 	<ul style="list-style-type: none"> I think a scheme may be used to teach mathematics I would be not have to expect a scheme to build everything up. Pupils are equipped by ability. The quick may learn things. It's useful to have someone who's a function and would be someone who's able to do something. If we're doing something which they all seem to be working on then they are put all together. It's very rare, I think that we do anything on a class basis all together. Unless it's a question scheme. It's useful to have pupils to approach a situation to understand the mathematics.
Not applicable	<ul style="list-style-type: none"> A tool for everyday life & for entering further maths as the most important one, followed by the dev. of reasoning skills. Doesn't consider appreciation and curriculum as important aims 	<ul style="list-style-type: none"> Features refer to a question relating to learning of maths and to a question about it often. He doesn't see it as being able to discuss things by themselves. Emphasis put on ability to question. There is more than one way to get a solution, and don't compromise the role of basic ability. 	<ul style="list-style-type: none"> Pupils discuss and work individually but takes on some of the teaching. Follows a method which is not too much of a routine.

	PERSON	NAME	TRAIT	CHARACTER	TEMPERAMENT	PHYSICAL	EMOTIONAL	INTELLIGENCE
JOHN	1. Teach moral - enjoy teaching	2. Humane - kind	3. Kind not hard to get a friend	4. Not afraid of the dark	5. Sensitive - only one who can be trusted	6. Short on legs	7. Very sensitive	8. Not afraid of the dark
	9. Kind not hard to get a friend	10. Humane - kind	11. Kind not hard to get a friend	12. Not afraid of the dark	13. Sensitive - only one who can be trusted	14. Short on legs	15. Very sensitive	16. Not afraid of the dark
	17. Kind not hard to get a friend	18. Humane - kind	19. Kind not hard to get a friend	20. Not afraid of the dark	21. Sensitive - only one who can be trusted	22. Short on legs	23. Very sensitive	24. Not afraid of the dark
JOSEPH	25. Kind not hard to get a friend	26. Humane - kind	27. Kind not hard to get a friend	28. Not afraid of the dark	29. Sensitive - only one who can be trusted	30. Short on legs	31. Very sensitive	32. Not afraid of the dark
	33. Kind not hard to get a friend	34. Humane - kind	35. Kind not hard to get a friend	36. Not afraid of the dark	37. Sensitive - only one who can be trusted	38. Short on legs	39. Very sensitive	40. Not afraid of the dark
	41. Kind not hard to get a friend	42. Humane - kind	43. Kind not hard to get a friend	44. Not afraid of the dark	45. Sensitive - only one who can be trusted	46. Short on legs	47. Very sensitive	48. Not afraid of the dark
DEBBIE	49. Kind not hard to get a friend	50. Humane - kind	51. Kind not hard to get a friend	52. Not afraid of the dark	53. Sensitive - only one who can be trusted	54. Short on legs	55. Very sensitive	56. Not afraid of the dark
	57. Kind not hard to get a friend	58. Humane - kind	59. Kind not hard to get a friend	60. Not afraid of the dark	61. Sensitive - only one who can be trusted	62. Short on legs	63. Very sensitive	64. Not afraid of the dark
	65. Kind not hard to get a friend	66. Humane - kind	67. Kind not hard to get a friend	68. Not afraid of the dark	69. Sensitive - only one who can be trusted	70. Short on legs	71. Very sensitive	72. Not afraid of the dark
DAVID	73. Kind not hard to get a friend	74. Humane - kind	75. Kind not hard to get a friend	76. Not afraid of the dark	77. Sensitive - only one who can be trusted	78. Short on legs	79. Very sensitive	80. Not afraid of the dark
	81. Kind not hard to get a friend	82. Humane - kind	83. Kind not hard to get a friend	84. Not afraid of the dark	85. Sensitive - only one who can be trusted	86. Short on legs	87. Very sensitive	88. Not afraid of the dark
	89. Kind not hard to get a friend	90. Humane - kind	91. Kind not hard to get a friend	92. Not afraid of the dark	93. Sensitive - only one who can be trusted	94. Short on legs	95. Very sensitive	96. Not afraid of the dark
MARIE	97. Kind not hard to get a friend	98. Humane - kind	99. Kind not hard to get a friend	100. Not afraid of the dark	101. Sensitive - only one who can be trusted	102. Short on legs	103. Very sensitive	104. Not afraid of the dark
	105. Kind not hard to get a friend	106. Humane - kind	107. Kind not hard to get a friend	108. Not afraid of the dark	109. Sensitive - only one who can be trusted	110. Short on legs	111. Very sensitive	112. Not afraid of the dark
	113. Kind not hard to get a friend	114. Humane - kind	115. Kind not hard to get a friend	116. Not afraid of the dark	117. Sensitive - only one who can be trusted	118. Short on legs	119. Very sensitive	120. Not afraid of the dark
PAUL	121. Kind not hard to get a friend	122. Humane - kind	123. Kind not hard to get a friend	124. Not afraid of the dark	125. Sensitive - only one who can be trusted	126. Short on legs	127. Very sensitive	128. Not afraid of the dark
	129. Kind not hard to get a friend	130. Humane - kind	131. Kind not hard to get a friend	132. Not afraid of the dark	133. Sensitive - only one who can be trusted	134. Short on legs	135. Very sensitive	136. Not afraid of the dark
	137. Kind not hard to get a friend	138. Humane - kind	139. Kind not hard to get a friend	140. Not afraid of the dark	141. Sensitive - only one who can be trusted	142. Short on legs	143. Very sensitive	144. Not afraid of the dark
KATIE	145. Kind not hard to get a friend	146. Humane - kind	147. Kind not hard to get a friend	148. Not afraid of the dark	149. Sensitive - only one who can be trusted	150. Short on legs	151. Very sensitive	152. Not afraid of the dark
	153. Kind not hard to get a friend	154. Humane - kind	155. Kind not hard to get a friend	156. Not afraid of the dark	157. Sensitive - only one who can be trusted	158. Short on legs	159. Very sensitive	160. Not afraid of the dark
	161. Kind not hard to get a friend	162. Humane - kind	163. Kind not hard to get a friend	164. Not afraid of the dark	165. Sensitive - only one who can be trusted	166. Short on legs	167. Very sensitive	168. Not afraid of the dark

APPENDIX B.5: Meta-matrix of the shifts in the participants' attitudes towards mathematics and mathematics teaching

	Nat of Math		Sch. Math		ipol Math	Basic Skills	Math. Dem.	1st Solun for
	out	int	out	int	creative	-	U ⁺	U ⁻
 Ana	Yes	No	Yes	Yes				
Clara	Yes	No	Yes	Yes	Reg.	+	0	U ⁻
Theresa	No	No	No	No	Expln	-	U ⁺	0
Emilia	Yes	No	No	Yes	How to Teach	0	+	0
Nana	Yes	No	Yes	No	No	0	0	-
Lucia	Yes	Yes	Yes	No	No	U ⁻	0	+
 Alicia	Yes	No	Yes	Yes	Reg.	+	5	U ⁺
Sara	No	No	No	No	No	U ⁻	0	U ⁺
Rosa	No	No	No	No	No	+	+	0
 Maria	Yes	No	No	Yes	No	+	+	0
Yara	Yes	No	No	No	Logical	+	U ⁺	0
John	Yes	Yes	Yes	Yes	Math Teaching	+	0	+
Diana	Yes	Yes	No	No	Teaching	+	U ⁻	+
Dani	Yes	No	No	No	Reg.	-	U ⁻	+
Kater	Yes	Yes	Yes	Yes	Reg.	+	U ⁻	0
Mark	Yes	Yes	Yes	No	Reg.	+	+	+
 Emily	Yes	Yes	Yes	No	Reg.	+	+	+

APPENDIX B.6: Example of an interaction profile

JOHN

	1	2	3	4	5	6
1. ORG IN/GR	1. ORG 2. ORG 3. ORG 4. ORG	1. ORG 2. ORG 3. ORG 4. ORG	1. ORG 2. ORG 3. ORG 4. ORG			1. ORG 2. ORG 3. ORG 4. ORG
2. TAG/PROP RPT/SIT	1. TAG/PROP 2. TAG/PROP 3. TAG/PROP 4. TAG/PROP	1. TAG/PROP 2. TAG/PROP 3. TAG/PROP 4. TAG/PROP	1. TAG/PROP 2. TAG/PROP 3. TAG/PROP 4. TAG/PROP			1. TAG/PROP 2. TAG/PROP 3. TAG/PROP 4. TAG/PROP
3. RES/ENT D-M-R						1. RES/ENT 2. RES/ENT 3. RES/ENT 4. RES/ENT
4. LEARN EX/CD	1. LEARN 2. LEARN 3. LEARN 4. LEARN	1. LEARN 2. LEARN 3. LEARN 4. LEARN				1. LEARN 2. LEARN 3. LEARN 4. LEARN
5. EXTYPE SL/MS	1. EXTYPE 2. EXTYPE 3. EXTYPE 4. EXTYPE					1. EXTYPE 2. EXTYPE 3. EXTYPE 4. EXTYPE
6. GDTYPE GP/LP	1. GDTYPE 2. GDTYPE 3. GDTYPE 4. GDTYPE	1. GDTYPE 2. GDTYPE 3. GDTYPE 4. GDTYPE	1. GDTYPE 2. GDTYPE 3. GDTYPE 4. GDTYPE			1. GDTYPE 2. GDTYPE 3. GDTYPE 4. GDTYPE
7. S:CA CH'UA	1. S:CA 2. S:CA 3. S:CA 4. S:CA		1. S:CA 2. S:CA 3. S:CA 4. S:CA			1. S:CA 2. S:CA 3. S:CA 4. S:CA
8. RE:W OS/EW	1. RE:W 2. RE:W 3. RE:W 4. RE:W					1. RE:W 2. RE:W 3. RE:W 4. RE:W
9. MATHIC	1. MATHIC 2. MATHIC 3. MATHIC 4. MATHIC	1. MATHIC 2. MATHIC 3. MATHIC 4. MATHIC	1. MATHIC 2. MATHIC 3. MATHIC 4. MATHIC			1. MATHIC 2. MATHIC 3. MATHIC 4. MATHIC
KEY						
SIN	1. SIN 2. SIN 3. SIN 4. SIN	1. SIN 2. SIN 3. SIN 4. SIN	1. SIN 2. SIN 3. SIN 4. SIN			1. SIN 2. SIN 3. SIN 4. SIN
EDIT	1. EDIT 2. EDIT 3. EDIT 4. EDIT	1. EDIT 2. EDIT 3. EDIT 4. EDIT	1. EDIT 2. EDIT 3. EDIT 4. EDIT			1. EDIT 2. EDIT 3. EDIT 4. EDIT
SHM						
PEOS	1. PEOS 2. PEOS 3. PEOS 4. PEOS	1. PEOS 2. PEOS 3. PEOS 4. PEOS	1. PEOS 2. PEOS 3. PEOS 4. PEOS			1. PEOS 2. PEOS 3. PEOS 4. PEOS
END						
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[illegible]

APPENDICES C:

Overview of the Logo course sessions

APPENDIX C.1: Overview of the course sessions in England


1st Session <ul style="list-style-type: none"> • Introduction • Computers, Logo and Maths • "Hands-on": Explore, Discover and Draw with the turtle • "Hands-on": Labyrinths and Maps (see Appendix D.6) • Group discussion 	2nd Session <ul style="list-style-type: none"> • "Turtling" with the Floor Turtle • Playing Turtle • "Hands-on": "Playing with Words" (see Chapter 4) • "Hands-on": Free exploration
3rd Session <ul style="list-style-type: none"> • Managing the computer • "Hands-on": Variations on a theme — 88 Olympic Games • "Hands-on": "Playing with Words" or Letter Patterns 	4th Session <ul style="list-style-type: none"> • Playing Logo: Procedures and Superprocedures • "Hands-on": "Chessboard and others" (See Appendix D.8) • "Hands-on": "Investigating Circles"
5th Session <ul style="list-style-type: none"> • The "Robots Game" (see Chapter 4) • "Hands-on": Free exploration or "Chessboard" and others • "Hands-on": Building blocks — Triangles and Squares • Group discussion 	6th Session <ul style="list-style-type: none"> • The "Robots Game" • "Hands-on": Recursion • "Hands-on": "Investigating Stars" (see Appendix D.10) • Video Film presentation: "Turning Point"
7th Session <ul style="list-style-type: none"> • "Hands-on": Free exploration • Playing Logo: Recursion • "Hands-on": More about recursion • Group discussion 	8th Session <ul style="list-style-type: none"> • "Hands-on": "Investigating Spirolaterals" or free exploration • Group discussion • Small group discussion: planning the Logo Microworld (see Appendix D.12)
9th Session <ul style="list-style-type: none"> • "Hands-on": Talking with the computer (words and lists) • "Hands-on": Animation • "Hands-on": Getting started with the Logo Microworlds 	10th Session <ul style="list-style-type: none"> • "Hands-on": Free exploration • "Hands-on": Logo Microworld • Group discussion
11th Session <ul style="list-style-type: none"> • "Hands-on": Free exploration • "Hands-on": Logo Microworld • Simulation of a school meeting: Is their a place for Logo in the school? 	12th Session <ul style="list-style-type: none"> • "Hands-on": Free exploration • Presentation by the course participants of the Logo Microworlds • Presentation by the course participants of individual projects

APPENDIX C.2: Overview of the course sessions in Portugal

1st Session <ul style="list-style-type: none"> • Introduction • Computers, Logo and Maths • "Hands-on": Explore, Discover and Draw with the turtle • "Hands-on": Labyrinths and Maps (see Appendix D.6) • Group discussion 	2nd Session <ul style="list-style-type: none"> • "Turtling" with the Floor Turtle • Playing Turtle • "Hands-on": "Playing with Words" (see Chapter 4) • "Hands-on": Free exploration
3rd Session <ul style="list-style-type: none"> • Managing the computer • "Hands-on": Variations on a theme — 88 Olympic Games • "Hands-on": "Playing with Words" or Letter Patterns 	4th Session <ul style="list-style-type: none"> • Playing Logo: Procedures and Superprocedures • "Hands-on": "Chessboard and others" (See Appendix D.8) • "Hands-on": Free exploration
5th Session <ul style="list-style-type: none"> • "Hands-on": Free exploration • "Hands-on": "Investigating Circles" • Group discussion 	6th Session <ul style="list-style-type: none"> • The "Robots Game" (see Chapter 4) • "Hands-on" Building blocks — Triangles and Squares • "Hands-on": "Investigating Stars" (see Appendix D.10) • Group discussion
7th Session <ul style="list-style-type: none"> • Playing Logo Again: Procedures and Superprocedures • "Hands-on": Free exploration or "Investigating Stars" (see Appendix D.10) • Video Film: "Turning Point" 	8th Session <ul style="list-style-type: none"> • "Hands-on": Free exploration • "Hands-on": Recursion • Small group discussion: planning the Logo Microworld (see Appendix D.12)
9th Session <ul style="list-style-type: none"> • "Hands-on": Talking with the computer (words and lists) • "Hands-on": Free exploration or Recursion • "Hands-on": Getting started with the Logo Microworlds 	10th Session <ul style="list-style-type: none"> • Playing Logo: Recursion or Animation • "Hands-on": Logo Microworld • Group discussion
11th Session <ul style="list-style-type: none"> • "Hands-on": More about Recursion • "Hands-on": Free exploration • "Hands-on": Logo Microworld 	12th Session <ul style="list-style-type: none"> • "Hands-on": Free exploration • Presentation by the course participants of the Logo Microworlds • Simulation of a school meeting: Is there a place for Logo in the school?

APPENDICES D:

Learning materials for the Logo course



Turtle Commands

To move the turtle

FD

number

→

BK

number

←

To turn the turtle

RT

number

↻


LT

number

↻

Candido Moreira - Setembro 1986

APPENDIX D.1: The "Turtle Commands" Handout



More Turtle Commands

Pen Commands

PD

PU

PE

To slow and hide the Turtle

ST

HT

APPENDIX D.2: The "More Turtle Commands" Handout

Teaching New Words...



You can teach new words to the Turtle... PROCEDURES...

```

?TO name
}
}
eg:
TO SQUARE
FD 80 RT 90
FD 80 RT 90
FD 80 RT 90
FD 80 RT 90
END
    
```

See what happens when you type the word SQUARE

And you can use your new word as any other Logo command!

Teach a new word to the Turtle using SQUARE as an instruction

```

TO FLAG
BK 100
FD 100
SQUARE
END
    
```

Recursion Recursion Recursion...



Define the following procedure:

```

TO SPIRAL :SIZE
FD :SIZE RT 90
SPIRAL :SIZE + 10
END
    
```

Can you predict what picture do you get when you type in SPIRAL 20?

This procedure calls a copy of itself before it finishes. The copy calls another copy which calls another copy...

That is a recursive procedure... The process doesn't come to an end unless you introduce a stop condition:

```

TO SPIRAL :SIZE
IF :SIZE > 100 [STOP]
FD :SIZE RT 90
SPIRAL :SIZE + 10
END
    
```

Try other recursive procedures.

Labyrinths and Maps

Purposes.

1. To provide practice in the use of the Logo basic primitives.
2. To develop skills in estimation of distances and angles.
3. To act as a catalyst for the acquisition of trial and error strategies as a means to solve a problem.

Pedagogical Approach

This activity provides a variety of tasks with diversified degrees of difficulty and openness (e.g. finding a solution versus posing a problem) in order to respond to the range of differences between the participants, but with a common situational and problem context for all.

Procedures

Labyrinths and maps of various kinds were drawn on transparent sheets. Each transparency was attached to the computer monitor screen. The participants (in pairs) should guide the screen Turtle through the labyrinth or to move it from one point to another on the map. Handouts placing the tasks in context were provided. Once the participants successfully complete one of the maps or labyrinths, they were directed to other one.

Follow-up Activities.

The labyrinths and maps could be used in connection with problems proposed by the participants.

Treasure Hunt



A modern pirate hid his gold treasure on a small island. So that he could locate his gold at a later date he drew a map of the island and made up a series of clues.

His clues were in form of Logo commands which would baffle his crew but shouldn't cause you any problems. Follow the instructions carefully and find the treasure!

- 1.Land on the small harbour in the Desert island facing North.
- 2.RT 90 FD 350 but be careful with the sharks
- 3.LT 90 FD 140 and beware of head hunters.
- 4.RT 90 FD 100 and use your umbrella.
- 5.RT 90 FD 60 but don't swim off this coast
- 6.LT 45 FD 350 and don't forget your oilskins
- 7.RT 135 FD 60. Here is the treasure under a large boulder.

Chessboard

Purposes.

- 1.To help to clarify further the idea of procedure.
- 2.To provoke the need to use mathematical ideas and relationships.
- 3.To develop awareness of the use of alternative approaches to solve a problem.
- 4.To encourage involvement in related non-Logo mathematical work.

Pedagogical Approach

This activity is intended to place a heavy emphasis on the use of conventional mathematics to solve a Logo problem, and making mathematical ideas meaningful, useful and attractive.

Procedures.

The activity was presented as a computer printout of a chessboard that participants (in pairs) had to recreate (without using the FILL command).

Follow-up Activities.

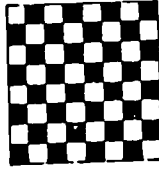
Hints were given to link the geometrical properties of the chessboard to arithmetical ones. In addition to problems associated with counting the number of squares in the chessboard, the participants were suggested to draw different kinds of chessboards (e.g. triangular ones). The activity was followed up by a group discussion in which the different groups of participants were invited to share their approaches to solve the task.

Chessboards and others ...



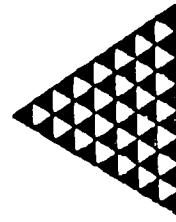
Use the Turtle to draw a chessboard.

How many white squares does the chessboard have? How many black ones? How many all together?



Draw another type of board with white and black squares

Now, draw a triangular board made of white and black triangles



How many white triangles does the board have? How many black ones? How many all together?

APPENDIX D.7: The "Chessboard" Activity

APPENDIX D.8: The "Chessboard" Handout

Stars Investigation

Purposes.

1. To provide familiarity with the use of procedures with variables.
2. To suggest regularities and differences that characterise polygons and stars.
3. To stimulate the search of patterns.
4. To help build up a view of mathematics as a dynamic activity with room for experimentation and discovery.

Pedagogical Approach

Underlying this activity is the expectation that it would help the participants to focus on non conventional aspects of conventional school mathematics, namely on "nonanswer-giving" phases of problem solving such as conjecturing and generalising.

Procedures.

Participants (in pairs) were initially encouraged to recreate a five-points star. Then, they were given a two variables procedure (TO POLISTAR :N :ANG/ :N) to explore and make conjectures about the pictures obtained for different inputs.

Investigating Logo Stars



Use the Turtle to draw a five points star.



You can use the following procedure to draw more stars

```
TO POLISTAR :N :ANG
  REPEAT :N [FD 100 RT :ANG / :N]
  END
```

Can you predict the pictures that get back you type in
POLISTAR 3 360, POLIESTR 4 360,....
etc.

```
POLISTAR 3 720, POLISTAR 4 720,....
POLISTAR 3 1080, POLISTAR 4 1080,....
```

Try other values . Look for stars
Can you see any relationship
between :N and :ANG ?

What other stars can you make
using this procedure?
Create constellations.

Developing a Logo microworld

Purposes.

1. To develop a mathematics Logo-based learning environment by drawing upon personal experience and that of peers.
2. To enhance and expand the participants' learning of Logo in a meaningful way.
3. To identify the participants' interests and concerns related to the teaching of mathematics.

Pedagogical Approach

This activity represents efforts to increase the participants control and responsibility over aspects that matter their pupils' mathematical learning. Moreover, by working in group in trying to solve the same problem the participants are led to talk about pedagogical issues which can help to foster reflection and learning.

Procedures.

The activity was carried out as a small group project and was extended for the last four course sessions. Previously, the participants (the whole group) were called upon discussing matters such as organization of working groups, identification of pupils difficulties and misconceptions in mathematics, and potential of a Logo environment as an alternative way to deal with these difficulties and misconceptions. Small groups were then formed on the basis of common interests and concerns. Each group had to decide on the project to develop and undertake the Logo work needed to accomplish the project. Finally, during the last course session the different groups were to present their projects to all the participants.

APPENDIX D.11: The "Logo Microworld" Activity



Logo Microworld

What is a Logo microworld?

A Logo-based environment designed to help to learn more effectively a mathematical topic area

It allows children to explore and discover for themselves without requiring them to use complex programming ideas.

The presentation of the Logo microworld should include

- the topic area it approaches
- difficulties pupils normally have with that topic area
- possible advantages of using it
- its possible extensions
- how to use it
- the Logo computer program

APPENDIX D.12: The "Logo Microworld" Handout

APPENDICES E:

The profiles of the participants in the attitude survey

APPENDIX E.1: The Respondents' profiles

The respondents' biographical characteristics

Age

The age of the English respondents ranged from 21 to 63. The average age of the respondents was 40.5, and both the median and mode were 40. The distribution of ages is nearly symmetrical, suggesting that the primary teaching force in England has been relatively stable. In Portugal, the respondents' ages ranged from 20 to 66. The average age of the Portuguese respondents was 39.2, the median 38.0 and the mode 32.0. The distribution is skewed towards the younger ages. This tendency may be taken as an indication that in recent years the profession has attracted more young people than in the past.

For purposes of comparison with the data available, it was decided to recode the variable into four categories: (a) under 29 years; (b) 30 to 39 years; (c) 40 to 49 years; and (d) 50 and over. Table E.1.1 shows, for both countries, the total number of the respondents broken down into those categories.

Table E.1.1: Distribution of the respondents by age compared with the national populations (in England and in Portugal)**

	England			Portugal		
	Nº of teachers	% of sample	% of national population*	Nº of teachers	% of sample	% of national population
under 30	74	13.3	13.0	196	17.2	21.2
30-39	176	31.7	33.5	446	39.2	34.8
40-49	207	37.3	31.0	287	25.2	24.6
50 and over	98	17.7	22.5	210	18.4	19.4
TOTALS	555	100.0	100.0	1139	100.0	100.0
Nil Response	25			17		

* Only primary

** Sources: *Education Statistics for the U.K.* (DES, 1988) and *Estatísticas na Educação* (Lisboa, 1987)

Compared with the national figures in England, the middle-aged group (40-49) of English respondents appeared to be over-represented while the older group (50 and over) seemed to be under-represented. The comparison, however, is complicated by the fact that the national figures do not include middle school teachers. But, one of the persons responsible by the Department of Education of Suffolk corroborated the idea that the older group of teachers respondents to the questionnaire was under-represented.

In Portugal, it is at the level of the young teachers that the differences between the respondents and of the national population are larger. Teachers under 30 might have been less motivated to answer the questionnaire, whereas teachers of age between 30 and 39 are over-represented. A plausible explanation for that is that younger teachers are probably less inclined to comply with authority than older teachers. Alternatively, the fact that the proportions of the under-40, and 40-or-over age groups in the sample and in the population are very close suggests that the differences may be due to fluctuations of the population.

Sex

Table E.1.2 shows the distribution of the English and Portuguese respondents according to sex, as well as the proportions of female and male primary teachers in Suffolk County Council and in Viseu district.

Table E.1.2: Distribution of the respondents by sex compared with the populations of Suffolk County council and of Viseu district**

	England			Portugal		
	Nº of teachers	% of sample	% of Suffolk population*	Nº of teachers	% of sample	% of Viseu population
Male	163	28.5	28.2	162	14.0	12.5
Female	409	71.5	71.8	993	86.0	87.5
TOTALS	572	100.0	100.0	1155	100.0	100.0
Nil Response	8			1		

* Combined primary + middle

** Sources: *Education Statistics for the U.K.* (DES, 1988) and *Estatísticas na Educação* (Lisboa, 1987)

As can be seen, the samples of respondents proportions in both countries are very close to the population proportions. In both countries, the primary teaching profession is predominantly composed of women. The most significant conclusion to be drawn from Table E.1.2 is that the discrepancy between male and female primary teachers is considerably higher in Portugal than in England. This may serve to emphasise the low-status of the profession in the former country.

Sex and age

Table E.1.3 shows the age distribution for the total sample, broken down by sex. It gives a somewhat clearer picture of the respondents' biographical characteristics.

Table E.1.3: Distribution of the respondents by sex within four age groups compared with the national population (in England) and of Viseu district (in Portugal)**

	England						Portugal					
	Nº of teachers		% of sample		% of national population*		Nº of teachers		% of sample		% of Viseu population	
	M	F	M	F	M	F	M	F	M	F	M	F
under 30	12	61	7.5	15.6	7.3	14.5	37	159	23.0	16.3	32.7	19.5
30-39	59	117	36.6	29.8	41.5	31.4	78	368	48.4	37.6	31.0	35.3
40-49	61	146	37.9	37.2	29.3	31.4	24	263	14.9	26.9	19.4	25.3
50 and over	29	68	18.0	17.3	21.9	22.6	22	188	13.7	19.2	16.5	19.8
TOTALS	161	392	100.0	100.0	100.0	100.0	161	978	100.0	100.0	100.0	100.0
Nil Response	25						17					

* Only primary

** Sources: *Education Statistics for the U.K.* (DES, 1988) and *Estatísticas na Educação* in Portugal (Lisboa, 1987)

This table reflects several facts. In Portugal, the percentage of male primary teachers under 40 (both in the sample and in the population) is bigger than the percentage of female primary teachers of the same age group. Two reasons may be found to explain the fact. Firstly, after 1975 the qualifications to entry to the teacher training institutions have raised from the equivalent of O-level to A-level, thus raising the status of the primary teaching profession. Secondly, by the same time the number of students allowed to enter the university decreased dramatically and therefore male students who would might have chosen university-based

careers were forced to choose other types of careers, including primary teaching. Furthermore, the figures also illustrate that the differences between the proportions of the sample and the population found in the Table E.1.1 were mainly due to the differences existing between the proportions of the male population and the male teachers in the sample.

In England, there are also divergences between the sample and the national proportions. However, the sample reflects the same characteristics as the national population in so far the differences between the percentages of male and female teachers of the under 29, and 30-to-39 age groups. It seems that considerably more women than men tend to choose a primary teaching profession for their careers. At a later stage, women teachers appear to leave the profession, probably for familiar reasons. This provokes an equilibrium between the percentages of female and male teachers of over 40 years.

The respondents' academic and professional experiences

Highest qualifications in mathematics

Table E.1.4 shows the distribution of the respondents considering their qualifications in mathematics while controlling for sex. As can be seen, in both countries, the vast majority of the respondents reported that they had an O-level or equivalent as their highest qualification in mathematics.

Of primary interest from a cross-country perspective is the considerably larger percentages of teachers (both male and female) in Portugal who have the equivalent to A-level in mathematics as compared to the proportions of the English respondents who hold similar qualifications. This discrepancy may be explained by reference to the fact that most of the different avenues offered to Portuguese pupils in the terminal year of secondary education include mathematics.

Table E.1.4: Distribution of the respondents by highest qualifications in mathematics while controlling for sex (in England and in Portugal)*

	England				Portugal			
	Nº of teachers		% of sample		Nº of teachers		% of sample	
	M	F	M	F	M	F	M	F
None	16	58	9.8	14.3	14	107	8.7	10.7
O-level or equiv.	100	287	61.3	70.6	94	635	58.0	63.9
A-level or equiv.	22	17	13.5	4.2	48	237	29.6	23.9
post-secondary	6	14	15.3	10.8	6	14	3.7	11.4
TOTALS	163	406	100.0	100.0	162	993	100.0	100.0
Nil Responses	11				1			

* Sources: *Education Statistics for the U.K.* (DES, 1988) and *Estatísticas na Educação* (Lisboa, 1987)

On the other hand, very few teachers in Portugal have a background in post-secondary mathematics. In England, in contrast, there is a high percentage of respondents indicating that they had taken mathematics at post-secondary level. These include non-award-bearing mathematics courses, Diploma in Education or B.Ed. with mathematics as one of the main subjects, and B.Sc. in mathematics.

An additional feature revealed by the table is that there are substantial differences between female and male teachers concerning their highest qualifications in mathematics. In both countries, there are more male teachers holding an A-level (or equivalent) or post-secondary mathematics than female ones. Interestingly, the magnitude of the difference is considerably higher in England than in Portugal.

Academic qualifications (initial and further)

Given that forms of teacher training have changed over time, the respondents' initial academic qualifications are in most cases a reflection of the time in which they were educated rather than a matter of choice. Moreover, given the differences of the type of teacher training between the two countries, these qualifications can hardly be the object of cross-country comparison. For those reasons, the distributions of the type of the respondents' initial academic qualifications are not reported here.

However, it will be interesting to state here the figures corresponding to the teachers who gained further academic qualifications after having entered the profession. In England, about 16% of the respondents have acquired further qualifications. Not surprisingly, most of these concerned education. Sixteen individuals indicated that they held a higher degree. In the case of Portugal, on the other hand, only 14 respondents (little more than one percent) reported that they had obtained further academic qualifications, mostly non-award-bearing courses at University level. These figures may accurately reflect the idiosyncratic characteristics of the primary teaching profession in Portugal. First, requirement of equivalent to A-level qualifications to enter tertiary education may make such an option open only to a small minority of teachers. Second, given that teachers' salary is irrespective of their qualifications, the motivation to acquire further qualifications may be quite low. Finally, it is likely that teachers who acquire further academic qualifications often tend subsequently to abandon the profession. Whatever the reasons may be for the differences, data of this survey confirm the lower general level of formal education among the Portuguese primary teachers.

A further area of comparability may be with regard to the proportions of English teachers opting for the two current forms of teachers training (B.Ed., and B.A. or B.Sc. plus P.G.C.E.). Interestingly, there were exactly the same number of respondents with those two types of initial qualifications. However, a substantial degree of selection by gender could be noted. The B.Ed. option appears to appeal considerably more to women than men, whereas the alternative is more likely to be chosen by men.

Other type of teaching experience

Table E.1.5 shows the percentage of teachers who reported that they had been engaged in some type of teaching of experience beside primary school teaching. Teachers included in the "other" category had a diversity of teaching experiences. In England, these include mostly teacher training and further education. In Portugal, the most salient ones are teacher training and teaching adults at primary level.

Table E.1.5: The respondents' teaching experiences besides primary teaching (in England and in Portugal)**

	England		Portugal	
	Nº of teachers	% of sample	Nº of teachers	% of sample
none	404	69.7	898	77.7
TV or 5th/6th grade*	-----	-----	130	11.2
Sec. (or Preparatory*)	114	19.7	57	4.9
Other	62	10.7	71	6.1
TOTALS	580	100.0	1156	100.0

* This is not applicable to teachers in England

** Sources: *Education Statistics for the U.K.* (DES, 1988) and *Estatísticas na Educação* (Lisboa, 1987)

As expected, a higher percentage of primary teachers in England than in Portugal had this kind of experience. The contrast is even more striking if one does not consider teaching fifth and/or sixth graders (or being a monitor of TV transmitted lessons) as an experience essentially different teaching primary school children. Thus, very few Portuguese primary teachers have any substantially different experience from primary teaching (in terms of the subject matter that

they have to teach, as well as the culture of the schools in which they teach). This may have implications at the level of socialisation and openmindedness of the respondents in Portugal .

Length of primary teaching experience

The mean number of years of primary teaching experience for the English respondents was 14.0. The median and the mode were respectively 14.0 and 12.0. In Portugal the mean, median and mode concerning the distribution of the respondents' length of primary teaching experience were respectively 16.6, 16.0 and 15.0. This means that primary teachers in Portugal tend to remain in their jobs for more years than their colleagues in England. This might be due to the characteristics of the primary teachers' qualifying course in Portugal, which makes retraining for other jobs difficult. The lower degree of specialisation of primary teaching qualifying courses in England, in contrast, makes it easier for primary teachers to take up other jobs. Moreover, it is likely that in England many teachers receive promotion to positions that involve little or no teaching. A further plausible explanation has to do with the already suggested tendency of female teachers to leave the profession for some years to resume it later.

Further comparisons between the respondents' primary teaching experience in both countries can be derived from the figures shown in Table E.1.5. In this table, the variable length of primary teaching experience was broken down into five categories (the same categories as those used in the study of primary teachers' opinions by Ashton *et al.*, 1975¹).

Table E.1.6: The respondents' length of primary teaching experience (in England and in Portugal)*

	England		Portugal	
	Nº of teachers	% of sample	Nº of teachers	% of sample
under 1 year	13	2.3	26	2.3
1-4 years	73	12.8	121	10.7
5-10 years	110	19.2	181	16.0
11-20 years	265	46.3	422	37.3
over 20 years	111	19.4	382	33.0
TOTALS	572	100.0	1132	100.0
Nil Response	8		24	

* Sources: *Education Statistics for the U.K.* (DES, 1988) and *Estatísticas na Educação* in Portugal (Lisboa, 1987)

Perhaps the most salient fact is that about a third of the Portuguese respondents have been teaching for more than 20 years, a percentage considerably higher than that of teachers in England. Another feature of interest is that in both countries the percentage of respondents with less than one year of primary teaching experience is exactly the same. Moreover, the proportions of respondents with one to four years of teaching experience are not very different either, thus suggesting that in both countries the profession has attracted similar numbers of young people.

Posts of responsibility within the school system.

In England, holding posts of responsibility related to teaching is a significant feature of the formal education system. Indeed, more than half of the English respondents (about 55%) reported that they have held a position of responsibility within the school system. Of special significance is the fact that over 14% of the English respondents reported that they have had a post of responsibility related to mathematics and/or computers.

¹ Ashton, P., Kneen, P., Davies, F. and Holley, B. (1975). *The aims of primary education: A survey of teachers' opinions*. London: MacMillan Education

These figures are in striking contrast with those obtained in Portugal. In this country, only about 10% of the respondents reported that they have held a post of responsibility within the school system. The difference between the percentages of teachers in the two countries who have held such posts might be due to the centralised versus decentralised systems distinction. In addition, it is possible that the term "responsibility related to teaching" may have been interpreted differently in the two countries. For example, given the fact that the post of "head of the school" in Portugal is mainly an administrative job and does not yield special status, it is likely that many teachers did not consider it when they answered to the question. Also, there seems to have been some degree of confusion among the Portuguese teachers about what was being asked in this question and what was meant in the question related to other possible teaching experiences. Consequently, the percentage of the Portuguese respondents who reported having held a post of responsibility related to teaching is likely to be an underestimate.

The respondents' 'special' professional experiences

Attendance at in-service courses in mathematics education (in the last five years)

In an attempt to distinguish between the nature of the in-service courses, the respondents were asked to give the titles of the courses attended, their duration and the date in which they were held, as well as the courses organisers. It is interesting to note that these questions yielded a considerable amount of missing information. For the purpose of cross-country comparison, however, the differences between the two countries are so striking that that kind of information is hardly needed.

In England, about two thirds of the respondents reported that they have attended at least one in-service course in mathematics education in the last five years. Significantly, a considerably high percentage of respondents (over 22%) had attended, in fact, to four or more in-service courses, and 4% had attended at least one long in-service course (twelve sessions or more). In the case of Portugal, perhaps it will suffice to say that about two thirds of the respondents reported that they had not attended any in-service course in the last five years. None of this is surprising given that, as suggested in Chapter 1, in Portugal, in contrast to England, the opportunities offered to teachers to attend in-service courses have been rather limited.

Use of computers in mathematics lessons

The question addressing this issue was preceded by one asking about the number of computers available in the respondent's school. It appears from the responses to this question that almost every primary school in Suffolk has acquired at least one microcomputer. (Only one respondent indicated that his school had no computer, whereas 17 teachers did not answer this question). About half of the respondents reported that their schools have three or more computers. Suffolk schools appear, therefore, to be relatively well-provided with computers. However, in spite of such wide provision of computers, only a minority of teachers (about 37%) reported that they regularly used computers in their mathematics lessons. It is clear that there are obstacles and difficulties in using computers in the classroom (one of which may be coping with changes in the teacher's role that this can require) that the majority of respondents are not prepared to meet. Of the teachers who have been using computers in their mathematics lessons only 74 (about 13% of the total number of respondents) reported that they have used Logo.

There is hardly room for cross-country comparison concerning the issue under scrutiny. As already stated in Chapter 1, computers were only recently introduced into a few Portuguese primary schools. Hence, for some Portuguese respondents the questions asking about whether their schools had computers available and whether they have been using them might have been appeared awkward. Other teachers, however, answered more positively. One respondent answered that there was no computer in his school, but that he had enough knowledge to use it. Another reported that there were some calculators in his school. Finally, one (and only one) teacher indicated that there was a computer in his school which he used regularly in his mathematics lessons.

APPENDICES F:

Four case-studies of attitude change

John's initial attitudes and motives for joining the course

John's motives for joining the course

John has already got some experience with Logo, which has probably enabled him to assess it as a potential tool "to make the teaching of mathematics exciting". Aware of this possibility, he appeared to have entered the course with the expectation that Logo could act as a catalyst to improve his teaching of mathematics. In addition, one can find career-related motives in John's motivation for joining the course. In fact, given the fact that he is the person responsible for computers in his school, the course could be seen as relevant in terms of his professional career.

John's initial attitudes towards computers

Readiness to use computers

John had already considerable experience with computers. He has been using them with his pupils since they first came in his school and as he put it "as often as possible". He was clearly very enthusiastic about working with them: "I've always seen them [computers] perhaps more favourably than some other people". Coupled with his experience with and enthusiasm for computers, he also seemed to be quite familiar with both software and hardware.

Orientation to the use of computers in mathematics

In his comments about the use of computer in education in general, and in mathematics in particular, John laid out some comments that suggest that sees the computer as a curriculum modifier. His opinion is best characterised by the following comment: "it should be used for something which is more than just a rather expensive workcard or skills practising thing". Another particularly important remark of John was related to the affective consequences of the use of computer in the classroom. Rather than seeing the computer as a 'carrot', John considered that one of the big advantages of the computer was with the less able children.

John's initial attitudes towards mathematics

Sensitivity to mathematics

John seemed to be a person who enjoyed mathematics and felt reasonably confident with it. He has taken maths to A-level, and although he did not pass, his recollections of his experiences with the subject at that time did not appear to reflect any kind of resentment: "I didn't find it terribly easy... but [...] formulae and working things out I used to enjoy once I got the idea and it was just like crossword puzzles...".

Views of (school) mathematics

The following comments during the pre-interview give some insight into John's views about mathematics:

It's about numbers and ah... it's a type of language, ahem... it's actually an easy language once you get to know the rules, ahem... and it helps you solve problems, and there are applications obviously to physics and sciences and ahem... again it has applications in its own right...

Implicit in these words seems to be a somehow rule-oriented view of mathematics dominated by his experiences with mathematics as a pupil, and in particular at A-level.

John's initial attitudes towards mathematics teaching

Pedagogical mathematical expertise

With considerable experience as a primary teacher, and having been recently awarded a B.Ed. Honours degree, John seemed to have come to a stage in which he was no more pleased with

his teaching of mathematics. It may be worth restating here his comments in reckoning his inability "to put [maths] across in a imaginative and enjoyable way":

the ability for imagination and free thought are perhaps less obvious to me... whereas with English and History you can look at things from very, very different angles without sort of boundary, whereas maths there seems to me or *there has seemed to me* [my italics]..oh you know, you teach addition this way, you teach subtraction this way...

In comparing mathematics with other subject matter areas, John seems to attribute his lack of ability for imagination in teaching mathematics to the characteristics of the subject itself. On second thoughts, however, he appears to bring forward the possibility of a new understanding of school mathematics. Such attitude of openness and initiative together with his considerable sensitivity to mathematics rendered him as a participant who was reasonably sensitive to new ideas concerning the teaching of mathematics.

Aims of teaching mathematics

John expressed a number of possible priorities for teaching mathematics which may be said to reflect both cultural values and his relatively high background in mathematics. For example, in the pre-interview, he commented: "I'd say that the basic one is to have a numerate population, to fulfil a perceived need of our employers, the public at large, the society...". On second thoughts and reflecting a typical 'child-centred' English primary teacher view, he added: "why are we teaching maths... yeah... I think that it's also something that can be fun and that... if can be made to be fun then it's a good reason as any for teaching it...".

Pedagogy/teaching strategies

In the main, John appeared to have negotiated a relatively very successful career as a teacher. He did not moan about his pupils nor did he complain about the conditions of his school. The only resentment he showed was against the 'National Curriculum' that was to come in one year's time.

When I came to examine John as a teacher, the impression I got was consistent with that I had got from his answers to the questionnaire and interview before the course started. An atmosphere of trust and cooperation between himself and his pupils, and among his pupils seemed to have flourished in John's classroom. Basically, pupils were grouped by ability and John would engage in mathematical work with each group per day, while other children would be doing other things. John's willingness to meet the individual needs and tap the diverse potentials of his pupils is one of the most important aspects of his pedagogy :

Children's concepts in maths are perhaps more personal than many other subjects. I've always tried to teach a child adding up the way she understands it... their understanding may not be the same for all the children in the group they're in...

Again, it is worth noting John's comparison between mathematics and other subjects. This time, however, there is a visible pendular swing towards a belief that has little to do with his somewhat rule-oriented perspective of mathematics.

Another relevant aspect of John's views of mathematics teaching is that of his sense of responsibility over the kind of learning that takes place in his classroom:

Teachers are very important actually in attitude and the way they teach maths... I think it is the same with any subject... I mean if you have a... the enthusiasm of the teacher... the ability of the teacher to put across in an imaginative and enjoyable way is very important...

One may well interpret these comments as a sign that there was an opening-up of John's conceptions of mathematics and that he was moving away from the idea that mathematics is a 'special' subject.

John's interactions with the course

Developing competence with Logo

Examination of the dribble files of John's work during the first and second sessions shows that John's knowledge of Logo on entering the course was little more than basic (for example, he tended to use non-Logo words borrowed from other programming languages or other types of software). As the course progressed his competence with Logo increased greatly. He produced an impressive amount of Logo work and developed a considerable expertise in programming with Logo. During the later course sessions (e.g. the Logo extended project) he felt at ease in using a range of Logo programming features -- from the most commonly used Turtle Graphics primitives to some basic Logo List Processing capabilities, and from defining and changing procedures with variables to tail recursive procedures.

Coupled with building competence with Logo, his enthusiasm with the course increased as well, probably feeding one another. The satisfaction he experienced during the course sessions whenever he achieved his stated goals or grasped a new idea were quite evident through his exclamations and his willingness to share his achievements. Clearly, he saw personal competence and development as an important issue.

The existence of computers in John's school allowed him to supplement "hands on" Logo experience between the course sessions. Because John was experienced and confident with computer hardware, the fact that the computer he had in school had a different operative system from the one he was using the course did not constitute a serious problem. Normally, he would come earlier to the sessions and redo the work done in his school. Another type of resource was his school library through which he had access to a variety of Logo materials. Such materials became a focal point for information. Often, John would bring to the sessions Logo related materials or alternatively some Logo ideas to explore.

As a learner of Logo, John was not a passive recipient of knowledge but an active knowledge seeker. For example, Logo ideas such as repetition and recursion were brought into the sessions by John although vaguely and imprecisely. At times, he even became a 'deviant member' ignoring almost totally my suggestions of Logo tasks. John's recognition that he was probably spending too much time with activities that he had set for himself at the expense of the suggested activities is well illustrated by the following incident. On one occasion, after having been utterly engaged in a self-initiated task, he came near me and said: "Now, I'll do what you want me to do".

An important characteristic of John that may have contributed to his development of competence with Logo was his ability to get along with others. John was able to negotiate solutions with and accept suggestions from others, and rely on his fellows if he felt the need for information. Moreover, he was interested in and used other partners' ideas as a source of inspiration.

Linking mathematics with Logo

Part of John's involvement in mathematical activity during the course may be attributed to his considerable sensitivity to mathematics too. This enabled him to reason logically and use mathematical concepts necessary to engage in Logo programming activity. Concomitantly, the Logo environment provided by the course offered the means to engage in mathematical activity which appealed to John. For example, powerful Logo tools such as the REPEAT command and recursion captured John's imagination. He became fascinated with these "fairly innovative" Logo-mathematical ideas and used them extensively. An illustration is offered by his interest in rotational patterns: after having succeeded with a project to draw a rotated pattern of trees in one session, John tended to use the same idea within new projects in the following sessions. Another good example is provided by his extensive use of recursion to explore spirals. Sometimes, John would be interested in exploring visual patterns on the screen, but this appeared to be intertwined with a curiosity to understand the mathematical ideas underlying these patterns.

Clearly, John's motivation for finding alternative ways to teach mathematics made it easier for John to accept the mathematical ideas and heuristics provided by the course activities. Moreover, John's considerable level of mathematical activity throughout the course and the style of this activity may have been triggered off by the fact that he was strongly attracted to computers and was interested in increasing his competence in working with them. Indeed, in attempting to make sense of Logo ideas, he had the opportunity to engage in doing mathematics in a meaningful way rather than disembodied and subject matter centred. In addition, John did not feel intimidated by computer error messages or even unexpected results. The computer and Logo led John to take personal responsibility for what he was doing and to develop higher-order mathematical skills, such as exploration of mathematical ideas, hypothesis generation and testing. For example, during some sessions he was interested in investigating the relationship between the number of points of a star and the turn angle in order to produce a 6-pointed star. Finally, he draw the conclusion: "there is no way of getting a 6-point star without lifting the pen. Only drawing a triangle and then another triangle". I suggest that in moving away from manipulating symbols without regard to their meanings to building mathematical knowledge, John was extending his understanding of the nature of mathematical activity.

A sense of John's involvement in mathematical activity while engaged in Logo work can be captured, for example, from his comments in referring to development of the extended group project.

While the end product might not have been valid, the sort of problems that we had to solve, which were to do with how far is it across the circle compared with how far round it is, how big is an angle, how big is a segment... all sorts of things like that we were using and talking about [...] it did give an opportunity actually to get the language of maths without being overtly [...] and you can actually talk about it in a much more concrete way and perhaps with a lot more understanding...

Implementing Logo in the classroom

Favourably disposed to use the computer and Logo in the classroom, John showed a marked willingness to use them in the classroom as part of the course requirement. He introduced them to his pupils at an early stage of the course and persisted in utilising them. Advocacy of and commitment to using Logo with his pupils may also have been inspired by the fact that John had reached a stage where he felt comfortable and was both prepared and motivated to modify his existing practices.

The implementation of Logo might have also been enhanced by school support and the fact that John was the person in charge for computers in school. Indeed, he managed to get the school to buy a Floor Turtle at the time of the Logo course. This is reminiscent of his remark in the pre-interview about the Floor Turtle: "If I can persuade people that Logo is a valuable support to the maths curriculum why shouldn't we have one". It is likely that the investment in the Floor Turtle, in turn, may have constituted a stimulus for John to integrate Logo work into his daily instructional activities

That pupils in John's class were familiar with the presence of the computer and of the Floor Turtle was clear when I visited his classroom the first time. It was interesting to note that my arrival and visit to the classroom did not seem to disturb their work. In contrast with what happened when I visited the classrooms of the Portuguese participants, in John's classroom there were no signs of special enthusiasm among the pupils working with the computer and the Floor Turtle. The task which the four children (two boys and two girls with evident different abilities) working at the computer were engaged in was the traditional Logo house. Routinely, they were taking turns to type in instructions without paying much attention to the traces left by the Floor Turtle. At a certain stage they even decided to work only with the screen turtle. The children seemed to be greatly dependent on John, immediately seeking his assistance when got stuck, rather than trying to negotiate among themselves a solution for their problem. In turn, John would ask questions to get the children to recall information previously learned "What is the instruction to stop the Floor Turtle?", "How many times do you have to repeat to get a square?", "What is the angle to make the turtle to go all the way around?".

John's approach to using Logo with his pupils appeared to be compatible with the three major features of his pedagogy/teaching strategies: crucial role of the teacher in directing children's activities, small-group work giving opportunity for collaboration among "slow" and "quick" pupils, and reliance upon teachers' aids. From his early implementation, and probably as a result of reflecting upon his and other participants' experiences with their pupils, John appeared to have begun to move to a different approach. Indeed, a quite different scenario was observed when I visited his classroom one month later. John's remarks during the final interview are consistent with my observations. When asked how he felt about implementing Logo with his pupils, he responded:

Excited. I think it has great potential, it's just that I didn't quite do it the right way.. I don't think [...] I tried using the screen as was used in one of the books we were recommended [...] I think they were working with older children ... [...] they went straight on to the screen and I think that younger children do need to see the turtle moving and they need to use their bodies to do things...

Reflecting upon pedagogical issues

As already stated, one of the most evident characteristics of John was his tendency for enjoying sharing ideas with peers. This openness to others' ideas may be regarded as central in encouraging John to reflect upon pedagogical issues. During the group discussions, for example, he was willing to share his approaches and strategies with others. He was also prepared to accept other participants' suggestions if these were considered reasonable and appropriate. For instance, having unfavourably assessed his own experience of introducing the Floor Turtle and Logo to his pupils, John was most likely stimulated by the description of other participant's experience when he decided to use an approach similar to that of this participant afterwards.

He was also open to my own suggestions. For example, he welcomed my hint for asking his pupils what they thought mathematics was about. He voluntarily brought the issue into light during the post-interview:

I did ask the question 'what is maths', and I did get the... fun came into it... It was quite interesting... They talked about numbers and all the obvious... [...] but I think they were beginning to realise that patterns and relationships, that some of the things they considered not to be mathematical were mathematical...

Another factor that might have contributed to leading John to reflect upon pedagogical issues was his considerable experience as a primary teacher. For example, it seems fair to say that his pedagogical mathematical expertise supported his ability to assume the role of group leader in the development of the Logo extended group project by selecting the mathematical topic to address (angles), one that at the initial interview he had identified as difficult for most pupils.

John's experience with the course seemed to have allowed him to go a step further in focussing attention upon the results of his actions in terms of children's response and for gaining new insight into their learning. At the end of the course, he was keen to see these ideas explored further:

I shall carry on doing it... [...] one has to be careful not to be too abstract too early, otherwise that can produce a sort of frustration in the kids which is destructive... We have our own Turtle on order and hopefully next term I'll be able to get some more work done... Having talked with you and found out the sort of things children can do on their own... Because I think that was one of the problems... I was trying to do it with them rather than giving them a problem like the one we've today...

Shifts in John's attitudes towards mathematics and mathematics teaching

The previous sections highlighted how John initiated the move for change himself, and continued that movement throughout the course. John reinforced his enthusiasm for and confidence in working with computers, and in addition developed a considerable level of Logo expertise. This encouraged him to engage in meaningful non-traditional mathematical activities

that prompted his interest and curiosity, allowing him to grasp an additional dimension to the use of computers in mathematics.

Engaging in Logo activity during the course also meant for John doing mathematics together with a new understanding of what mathematics is about. Even when he was interested in exploring the visual effects on the screen, he was aware of making using of mathematics to get them, as well as being interested in understanding the mathematical relationships embedded in the visual patterns. His frequent involvement with exploratory activities helped John broaden his views about the subject, from a somewhat static and rule oriented perspective to a more dynamic and creative one.

Entering the course with a motivation for change his mathematics teaching, John responded well to the challenges that it offered to him. Consistent with his broadened views of mathematics, he also appeared to have incorporated new ideas about teaching the subject: "It [the course] has taken me much more away from the practice. [...] It has broadened my perspective and horizon on what can be used to teach a concept and hopefully make teaching more interesting...". Three major shifts in his answers and comments related to his attitudes towards mathematics teaching could be noted. First, John's confidence as a responsible professional capable of taking autonomous actions (thus relying less in the usual teaching props) appeared to have increased. This might be associated with the sense of achievement that he got from his participation in the course, and in particular from the Logo group project. Second, he seemed to have found room to give his pupils a more active role in learning. Finally, he seemed to come see that teaching mathematics for its own sake is an important aim. The fact that he derived great satisfaction from his involvement with the course, and was fascinated by many of his mathematical 'discoveries' might explain this tendency.

APPENDIX F.2: The case of David

David's initial attitudes and motives for joining the course

David's motives for joining the Course

David had already some experience of using Logo. He spoke of Logo as providing the kind of flexibility and autonomy in pupils' learning that he valued. Logo appeared to be regarded by David as a tool which could challenge conventional practice. On entering the course, he was looking for some kind of input that would enable him to find how:

[...] I want to find out more, I want to find out about Logo, I want to know its applications from practitioners, from people who are more experienced than myself... its application in the infant classroom... *I might disagree* [my italics], I don't know...

However, as his comment "I might disagree" suggests, David entered the course with some scepticism. It remains an intriguing question whether such scepticism was about Logo or about my ability (due to my foreigner status) to run an in-service course for English teachers. In fact, there were several occasions in which I was struck by him questioning me about various issues (e.g. "Do you know Escher?", "Do you know what O-level is?").

David's initial attitudes towards computers

Readiness to use computers

David had already considerable experience with computers. He had established a strong relationship with them through his "world of words" (Turkle, 1984¹) when he used them for writing. Later, he might have regarded them as a way of reforming the formal educational system of which he was enormously critical. As the head of the English department in his previous school, he had taken the initiative to acquire a computer for his department, and as he took over his post as an infant teacher, he continued to use computers with his pupils.

In spite of his motivation to use computers there were no evident signs of personal enthusiasm. It was just that he felt that computers served a valuable function for him and his pupils:

I see them as a force for good, ahem... I see them as an aid to the reality of life, as a supplement to man's human intelligence, ahem... so very much that making life easier, and improving the quality of life...

Orientation to the use of computers in mathematics lessons

With very little experience of teaching the subject, David was not familiar with the use of computers in mathematics. Overall, his views about computers in mathematics were along the same lines as in any other subject: "I see it as an application anyway, sort of like a typewriter, you know, or a pencil or something... I mean it's a resource and as such you can use it creatively I believe in any subject...". When pushed to be more specific in relation to the use of computers in mathematics lessons, David ended up by referring to Logo and the opportunity that it gives to develop problem solving skills.

David's initial attitudes towards mathematics

Sensitivity to mathematics

Perhaps the most fundamental aspect of David's answers to both the attitude questionnaire and the interview before the course started was that that rendered him as a *mathephobic* pupil.

¹ Turkle, S. (1984). *The second self: Computers and the human spirit*. New York: Simon & Schuster.

Nowadays, he appeared to hold more 'favourable' feelings that he had in the past. However, the kind of emotional processes at work when throughout the course he had to deal with mathematics seemed to point to the opposite.

Views of (school) mathematics

One of most surprising David's comments in the pre-interview was caught in his answer to the question of what mathematics is about. Here is his response:

Oh dear... I just need to think about it for a minute, I think... I mean... I actually think it has to do, I mean this is off the top of my head in reaction to your question, but I think it has to do with a form of expression, but that's a very quick answer. I can see some faults in that... [...] I mean I could see other people saying well maths isn't about expression, it's about being able to give the right change or get the right change in a shop or whatever. But I think in some senses that it has to do with actually kind of ... yeah, how we express ourselves, how we live our lives...

My interpretation of the way in which David communicated his views of mathematics ("it has to do with the way we express ourselves") is that it represents an idealised and defective conception of the subject.

The above comments serve also to illustrate the verbose and somewhat theatrical manner in which David tended to express himself during the pre- and post-interviews. Moreover, they also highlight his predisposition to call into play what he indicated were other people's ideas. Since his teens, David was intensely discontented with the educational world and perceived himself as a nonconformist member in that universe. Concomitantly he was building his own utopian educational world. I wonder whether his tendency to focussing upon other people's views represents no more than bringing into light 'knots' (Wagner, 1987²) in his thinking resulting from the conflict between his ideal images and what he perceived as real.

David's initial attitudes towards mathematics teaching

Sensitivity to mathematics teaching

David's movement from the secondary into the infant sector seemed to have been accompanied by the hope that in the infant sector he would find his ideals of education. However, what David appeared to have faced as an infant teacher was the disorientation that tend to follow change. This seemed to be especially true with regard to the teaching of mathematics. Disliking and being little confident with mathematics, he was clearly anxious about how to teach the subject.

Another point that leaps out of David's comments during the pre-interview is his low sense of responsibility over what happens in the classroom. Often, he went on to cast responsibility for his pupils' poor ability in mathematics and attitudes towards the subject on social background factors. Moreover, he blamed the system rather than teachers (and therefore himself): "...well who's fault is it... it's not the people actually in the classroom, in some sense you can take it further down the scale... it's not the headteachers fault...". The system, for example, had not provided him with the help he needed when he looked for advice about how to go about his job.

Aims of teaching mathematics

In answering the attitude questionnaire, David gave priority to two aims: that of teaching mathematics for its own sake and that of preparing pupils to cope with real life. It is interesting that Howard had selected such aims, ones that are highly discordant with the experiences he seemed to have had with the subject as pupil. It was as if in opting for these two aims David was conveying the message 'I don't want that my pupils have the same kind of experiences with mathematics that I had'. In talking about the same topic during the pre-interview, David did not make any reference to have pupils enjoying mathematics for its sake:

² Wagner, A. (1987). 'Knots in teachers thinking'. In J. Calderhead (Ed.), *Exploring teachers' thinking* (pp. 161-178). London: Cassell.

I think... primarily to allow people to function at a fairly basic level and secondarily ahem... to allow people to think in a more abstract way, more quickly, and again it's back to problem solving... And I remember seeing your questionnaire and *I couldn't be sure... I don't think in the questionnaire I kind of gave the same answer* [my italics] but I guess yes, in thinking about it... it has to do with thinking processes...

This comment gives some insight into the kind of conflicts David found himself in trying to answer the question of why teaching mathematics. Not only was he aware that in answering the questionnaire he was not sure about his priority aims, he also admitted that he might have answered differently in the questionnaire and in the interview. Moreover, it is particularly relevant that in the interview David gave primacy to the disciplinary aim of teaching mathematics, a traditional goal that has little to do with his expressed perspective of the subject.

Pedagogy/teaching strategies

My impression of David's strategies/pedagogy to teach mathematics is that it was evolving from a tension reconciling his experience as a secondary teacher with what seems to be current directions in primary education in England. The following extract illustrates the sense of this tension:

I enjoy small groups, but in terms of introducing things I tend to do that in whole class, because I just can't find that... I'm not good enough in terms of organising my class, my record keeping, and so... I'm not good enough to introduce it to one small group and then get them doing that and then work with another group...

The appearance and layout of David's classroom was similar to those generally found in English primary classrooms. The room was profusely decorated with posters and displays, and there were different subject areas corners. In terms of instructional aids, he seemed to be "using a bit of everything" to help him to teach mathematics. The following comments are illustrative:

... a whole series of books... games ... There is the new ILEA book that they've just brought out on algorithms, that's a lot clearer, the old ILEA guidelines I got hold of them... number lines which is a new thing to me, again ahem ... this friend of mine suggested that I used calculators which wasn't an idea that had occurred to me. I got 6 calculators at her recommendation and the kids love them. I use them with number line, number work, number balances, things like that... And again a lot of these things are presented as toys as things to play...

This climate conducive to give pupils opportunities to organise diversified work notwithstanding, David seemed to use a structured and directed approach to teaching mathematics, although as he put it "this is less than satisfactory". Here is how he described the mathematical work he had engaged in with his pupils on the day of the pre-interview:

I set them all off on the same task... part of that is by way of trying to assess what they can and cannot do... For example, one of the things I set them, we were talking about time and the way the clock works... and I was aware that one or two of them knew like 1 o'clock, 2 o'clock and a lot of them didn't, so I needed to know for myself which ones could actually handle it... and so I gave them all the same exercise... put a clock face on and I wrote out this is three o'clock, and so the actual exercise was to write down the name for the number...

David's interactions with the Logo Course

Not developing competence with Logo

David regarded his involvement with the course exclusively in professional terms. Thus, the course activities that aimed at his own development with Logo were relatively unimportant. Clearly, they did not fit an order that he had established for himself. A direct consequence of this was that at the end of the course, David did not greatly increase his competence to deal with computers and Logo.

Critically important in making David's experience with the course a relatively unsuccessful one and hindering his growth with Logo was the course emphasis on self-directed and cooperative

learning. That he did not find in the course an environment that fitted his external orientation to learning is clear from his comment in the final interview when asked about what stood out for him:

I know about myself that I learn best from watching other people do things... So I found the video very useful. [...] I don't think I'm quite so good at ahem... discovering for myself, it does take an awful long time...

Given that as a teacher David seemed to be in favour of children's active makers of knowledge rather passive recipients, it is possible that his energy during the course was diverted away from learning to dealing with the unresolved conflict -- that of the discrepancy between his commitment to a constructivist perspective of pupil's learning and the belief that his own best way of learning was by being told what to do.

Moreover, David did not learn much from his interaction with his peers and even found in some occasions working with some of them an unpleasant experience. One may conjecture that his inability to relate other participants maximised the number of occasions that David needed to struggle alone with a problem, thus increasing his feelings of helplessness and anxiety.

As stated previously, David's main tie with the computer was by using it as an word processor. That his personal enthusiasm for computers was limited could be seen behaviour during the course sessions. When working with the computer, he would let others to take over if he was working with a peer or would interact with it contemplatively if he was working alone. Moreover, he lacked the confidence to handle hardware. Thus, a further reason that might have hindered David's building of competence with Logo was related to the lack of appropriate resources and assistance in his school. He had access to a computer in his school, but the Logo version he could run there was different from that he used in the sessions. Without assistance in his school, David experienced confusion and frustration, and felt discouraged to extend his Logo work between the sessions. He explicitly raised this issue in the post-interview:

I've found some logistical problems. For instance the instructions you gave us wouldn't work with a particular Logo disk...but also I got the one we were using at the Institute... didn't work...I then brought that back and there was something wrong with the way that it had been transferred, so I took it back again, got that sorted out brought it back and then it wouldn't print...

Not linking Logo with mathematics

Beyond other influences, the effect of David's immersion in a mathematical environment appeared to have had consequences of affective nature, through raising to salience old unfavourable feelings of inadequacy in relation to mathematics. Reentering a mathematics computer based course after years of absence from learning the subject David seemed to have experienced some anxiety and frustration.

David's attempt to draw a race track in the third session is illustrative of his relatively low sensitivity to mathematics. At a certain point in solving the task, he wanted to erase a semicircle and he could not figure out how to do it. He struggled and persisted in working out a solution for his problem without asking for any help. It was like he was embarrassed by his inability and did not want to show it to others. This feeling was probably exacerbated by the fact that he knew that figuring out problems on one's own was expected. Perhaps the most fundamental way in which his low ability to deal with mathematics was evidenced was that my intervention contributed little to help him in his attempts to solve the problem.

Clearly, David seemed disinclined to think of himself as able of thinking mathematically. One instance was recorded in which I thought David in working with a peer was feeling some excitement from mathematics and was in control of the mathematical processes involved in finding a solution to a Logo task. When in the post-interview I encouraged David to talk in retrospect about his involvement with this task, his low-confidence with mathematics came to surface once more:

Well he (the working partner) was very good, he was much faster in what I considered to be maths than I was... I seemed to be able to facilitate things on the keyboard with the turtle and so forth quicker than he could, I seemed to know what the turtle could do on the screen quicker than he could, but when I needed ahem... an equation worked out to find a particular angle he was much quicker than I was, faster at the computation in his head than I was... That says it all, for many years I've been telling myself that, you know, I can't do maths...

In this comment, David is also communicating a conception of mathematics different from that he had expressed before the course ("it has to do with the way we express ourselves"). He might have tried to transform his understanding of what mathematics is about in order to teach it, but throughout their interactions with the course he appeared to have resumed his old understanding again. There was an obvious tension between his "real" understanding of mathematics and his "ideal" conception of the subject. When asked whether he had learnt any mathematics during the course, he responded: "I hope you won't be offended if I say no... but I think that's because of my block about maths..."

Implementing Logo in the classroom

There seems to be little doubt that David regarded his involvement with the course in terms almost exclusively professional. That was probably why he found the video 'Turning Point' very useful, and he showed considerable involvement, yet with a secondary role, in the development of the Logo extended group project.

At the outset of the course, he also appeared to be greatly motivated to use Logo in the classroom, but his interest in so doing appeared to have diminished as the course progressed. For example, when I visited his class for introducing the Floor Turtle, almost two months after the beginning of the course, David's enthusiasm was limited. There was even a sense in which he was apprehensive about this visit. For example, when I arrived at his school he inquired me in a somehow disapproving way about the purpose of the visit. It is also worth noting that my visit to his class coincided with the time in which his pupils were attending a school assembly. I wondered whether David knew of this assembly when he scheduled the visit. At the end of the course, it was pretty obvious that he was reluctant to expose his class again, and therefore I ended up by not visiting it a second time.

Several reasons may be found to explain David's emergent lack of interest in using Logo with his pupils as part of the course requirement and five come to mind. First of all, David's lack of experience and confidence as an infant teacher may have limited the degree to which he was willing to try something new in the classroom. The same kind of reason may be used to justify why David was not willing to have his actions and those of his pupils scrutinised by an observer. An overlapping reason has to do with the fact that in joining the Logo course David appeared to want ready made Logo ideas to use with his pupils. In realising that he should take responsibility for the implementation of Logo in the classroom rather than being told exactly what to do, he might have questioned the worthwhileness of his participation in the experience. Third, David's customary idealism with a consequent dissatisfaction with the outside world might also have set constraints to what he could achieve through his participation in the course and in particular preventing him of seeing applicability of and relevance in the ideas and suggestions offered by the course.

Let me focus for a moment on what I could observe when I visited his classroom to introduce the Floor Turtle. In interacting with his pupils in the context of the Floor Turtle work, David centred his actions around a transmission paradigm following a whole-class teaching approach. All the children were sat submissively on the floor around a piece of paper on which David had placed a number line. He limited himself to ask a series of closed questions. Then, those pupils who want to answer would raise their hands and David would choose one of them to say a number. It was evident that they did not feel any enthusiasm or relevance in what they were doing. It was as if David's pessimism about his pupils had been communicated to them and they avoided to participate. If what I saw is typical of David's usual behaviour, then the gap between his expressed educational beliefs and instructional practices is undoubtedly big and is

probably causing him to be insecure and frustrated. For example, although espousing a belief such as "children being allowed flexibility", David seemed to be a too restrictive and directive teacher, not allowing for pupils initiative. At the beginning of the course, too, David associated computer and Logo activity with problem-solving. However, what I could see was no more than related to the acquisition of facts. It is probably fair to characterise David's teaching style in terms of a coping strategy.

Reflecting upon pedagogical issues

David's case is an interesting one. During the interviews and in informal meetings with myself, he revealed himself as deploying fluent powers of exposition and was eager to share his ideas and knowledge of various issues. In contrast, during the course sessions, David appeared to be a taciturn person. During the group discussions, for example, he preferred to listen to the other participants than to express his opinions. Moreover, as already suggested, in working with some of his peers he had difficulties concerning the negotiation of a viable cooperative relationship.

One way of interpreting the evident discomfort that David experienced during the group activities during the course is that he felt relatively little at ease to talk to primary teachers who were much more experienced than himself. In addition, given that most of the participants were not in the infant sector he might have felt that they did not share the same kind of interests and problems. During the later sessions, I got the impression that his experience in developing a Logo extended group project with another infant teacher was a gratifying experience for David. But David considered himself as playing a minor part in planning and developing that project. In referring to it during the post-interview he preferred to talk about Debbie's project. When I remarked that he had also contributed to the development of the microworld, he commented: "Well it was very slightly... I mean it was... I talked to her but she does things very quickly, you know she's one, two, three, and it's done...". Once again, David's low confidence came to the surface.

Where this is pointing to is to suggest that, with these low levels of interaction and cooperation with peers, it would be hard to see what kinds insights David could obtain that could be used to examine his attitudes and practices in light of others' experiences and opinions and "to take sides on issues". However, David might have come to reflect upon pedagogical issues as a result of his participation in the course. But rather than developing favourable thoughts with regard to the message conveyed by the course, he was rebelling against it. This appeared to have happened, in particular, with respect of his involvement with the Logo extended group project, as it suggested from the following comment at the post-interview:

At this sort of age, particularly with this group of children... they need immediate results, we talked about it in the group at the Institute. [...] Things are needed with that age range to be very big and immediate... Whilst I could make them persevere to draw a square, when they've pressed the button and the square is there... they do have the satisfaction... is much greater....I would then want to work backwards and say... hey you can draw this for yourselves, would it be nice would you like to draw a slightly smaller hexagon or a slightly smaller square or would you like to be able to draw smaller circles to give smaller eyes or whatever... or you know... and then to work back that way... facilitating that kind of process and that kind of work I think it actually opens up doors to someone doing more for themselves...

Although not in line with what was advocated by the course, this kind of understanding may be considered an interesting outcome in that it may constitute a step forward that David gave to move away from espousing abstract ideas about how children learn mathematics.

Shifts in David's attitudes towards mathematics and mathematics teaching
Coupled with a low sense of achievement, David seemed to have developed throughout the course frustration and resentment. His discontent with the course is well illustrated in his remarks at the final interview:

my expectations back in September probably weren't met, but were they good expectations to have in the first place [...] one of my presuppositions is that there's no failure, only feedback, so you know, if this isn't working then change the expectations and see what you get out of it...

The implication of David's disillusionment with the course was a variety of outcomes some of which were opposed to the intended ones. On the positive side, there seems to be some evidence that suggests that his participation in the course brought to sharper consciousness several aspects of his attitudes towards mathematics and mathematics teaching.

For example, as already stated, David did not regard the course as mathematical. There was, however, some evidence of his involvement (or rather lack of it) with mathematics. First, his difficulties with the Logo-mathematical activities caused him to 'rediscover' his block about mathematics. Moreover, his expressed views of mathematics were more elaborated and less idealistic at the final interview than at the initial one. Although he went on to say that "mathematics at the *highest level* is like an art form", he also gave an alternative perspective: "a facility for understanding the world through numbers, *at my level* [my italics]...".

His experience with the course also seemed to have represented a context for developing awareness of his conflicting views about mathematics education and to reconsidering his attitudes towards mathematics teaching. For example, it is an interesting reversal of opinion that David came to endorse the questionnaire item expressing that he generally demonstrates procedures and methods for performing mathematical tasks. It is possible that David combined his ideas about the role of the teacher with his own experience as a learner during the course, and in particular, his increased awareness that he was not good at discovering for himself.

The most striking example of shifts in David's opinions was, however, that that occurred in relation to the aims of teaching mathematics as expressed by his answers to the questionnaire: from a position in which he considered important all the aims for teaching mathematics except the curriculum efficiency aim to a viewpoint in which only this latter aim was judged priority. This perspective, nevertheless, should probably be seen as mere irony. That is, it is possible that in face of his disillusionment with the course David used his expressed opinions about the aims of teaching mathematics simply as a form of rebellion against the message conveyed by it.

In terms of the effect of the course on his attitudes towards computers, David commented: "I can't honestly say that my views have changed much as a consequence of the course. I did the course because I was very much kind of in favour of computers in the classroom". It is particularly significant that after the course when asked about his opinion about the use of computers in mathematics David stressed the fact that computers are not necessarily allied to mathematics, very much in the same way as he had reacted before the course. My impression is that the course had no effect on David's personal feelings towards computers. However, as far as the use of computers in mathematics lessons is concerned, it might have turned David away from Logo and led him to consider other less mathematically demanding forms of software.

APPENDIX F.3: The case of Alice

Alice's initial attitudes and motives for joining the course

Alice's motives for joining the course

When in the pre-interview Alice was asked about the reasons for joining the course, she said: "It's to try and learn what I can do with the Logo language in school". It was clear that she felt the need for developing greater awareness of the use of Logo in the classroom and understanding what she was trying to achieve with it. She spoke of a feeling of "being lost", and of having read a book about "Logo and the Logo philosophy" but not seeing how it could be related to practice.

Coupled with this concern, Alice seemed to have come to a stage in which she was interested in rethinking her teaching of mathematics. Indeed, in talking about mathematics in the pre-interview, she expressed dissatisfaction with the existing curriculum and even a certain discontent with her teaching of the subject.

Alice's initial attitudes towards computers

Readiness to use computers

Compared to the other Portuguese participants, Alice may be considered as a computer 'experienced' teacher. She has two computers in her classroom and has been using them with her pupils for about one two academic terms. It was clear that from the outset of the course she found herself relatively comfortable in using it. Remarking on her experience with computers and knowing that most of the other participants lacked it, she commented in the pre-interview: "I can help the other participants... Those who will be working with me would have some advantage...".

Orientation to the use of computers in mathematics lessons

In responding to the question addressing her orientation to the use of computers in mathematics lessons, Alice answered: "In mathematics I didn't use the computer yet, and so I don't know well... May be it can be used in geometry... and to do calculations... data bases... spreadsheets..., well I came across them but I didn't use them... I don't know...". These words seem to indicate that she was mainly perceiving the computer as a tool to support the existing curriculum. Further comments, however, suggested that Alice was also beginning to realise that the computer could be a curriculum *modifier*.

Alice's initial attitudes towards mathematics

Sensitivity to mathematics

In talking about her attitudes towards mathematics, Alice immediately recalled her relatively stressful experiences with the subject in secondary school. Her enthusiasm and confidence with mathematics appeared to be comparatively lower than the majority of the Portuguese participants. Meanwhile, she appeared to have developed a certain tolerance towards the subject, but as she stressed she was more "inclined to the arts".

Views of Mathematics

Alice appeared to see mathematics in three different compartments -- school mathematics, everyday life mathematics and what she called "higher mathematics". This very distinction emerged from the way she answered in the pre-interview to the question about what mathematics is:

Mathematics is a science ...It's a body of knowledge... It's a set of techniques to solve problems... to define certain things... to apply to everyday situations...to bake a cake, to put paper on wall...[...]

Well, mathematics is much more than that. Higher mathematics is much more than that, but I'm not able to define...

Reckoning her limitations to know what "higher mathematics" is about, Alice's remarks were obviously about mathematics of the primary school curriculum. Moreover, although she also mentioned the applications of mathematics to everyday life, outside school mathematics seemed to have little relevance for Alice. For Alice mathematics was mainly a 'following the rules' subject that demands "learning by heart of tables and dull calculations" and which has little room for personal and meaningful activity.

Alice's initial attitudes towards mathematics teaching

Pedagogical mathematical expertise

The most salient aspect of Alice's comments concerning mathematics teaching was her antipathetic disposition to the existing primary mathematics curriculum. On one occasion, for example, she commented:

I think that we teach things that are not relevant for children of this age... for instance, the volumes, the conversions... It is the theme that I'm going to teach now, but I don't like teaching it... It's very confusing, and children have problems with it...

This comment underscores the kind of conflicts to which Alice was exposed in teaching mathematics. Although critical of the existing curriculum, she appeared to see no alternative than conform to it.

Her feelings of insecurity in teaching mathematics may also be seen in the light of her lack of confidence in dealing with the subject. It is notable that when talking about herself as a teacher of mathematics, Alice mentioned her own learning experiences with the subject as pupil a few times. For example, in referring to pupils' difficulties with mathematics she commented: "When I was a pupil, teachers didn't worry to make things concrete. Now, you try and concretise all the time, and even though it's not easy for them". In another passage she said: "Now, pupils are not afraid of maths... They may not like it, but they are not anxious about it. It was not like when I was a pupil and I was always terribly afraid of maths...".

These references also suggest that Alice used her own experiences as a pupil as a main reference point in teaching mathematics. Moreover, in the absence of other sources of knowledge upon which she could basis her teaching of mathematics she appeared to depend strongly on the adopted textbook.

Aims of teaching mathematics

It seems fair to say that Alice's aims of teaching mathematics were essentially twofold: that of developing pupils' logical thinking and that of preparing pupils for further mathematics. The emphasis given to this latter aim may be said to be influenced by her view of (school) mathematics determined by a prescribed curriculum. The endorsement of such an aim is consistent with her frequent references to fragmented pieces of mathematics topics to be learnt and has obvious cultural connotations.

The focus on the former aim is more difficult to explain in face of Alice's prescriptive view of mathematics. One might attribute it to an implicit historical perspective of the subject which also has cultural overtones. The primacy given to this aim was consistently displayed by Alice when she spontaneously evaluated the textbook that she uses and which was adopted by the school: "I like it because I think it stresses the logical aspect of mathematics". That is, for Alice mathematics is useful in develop thinking, although how seemed not to be clear at all.

Pedagogy/teaching strategies

Alice's words about the way her pupils' organisation in the class are of interest:

They are arranged in groups of four... The groups are not homogeneous... they are almost formed at random... I've changed them often and I'm thinking of changing them again, because they cannot stay

too long together ... But initially, I tried to make sure that there were two of the best pupils and two of poor ones... At a certain stage I noted that they talked too much and I had to split them... Then I used a 'horse shoe' arrangement... Now, they are again in groups and the criterion I used in so doing was that of their order of registration...

It is easy to see that Alice was still looking for a pattern of classroom organisation. I wonder whether her uncertainty about the best way of grouping her pupils was a result of her recent initiative to incorporate computers into her teaching.

This comment points to another managerial aspect concerning pupils' learning. It seems clear from this account, that in organising pupils in groups Alice was trying to encourage cooperation among them, whereas in splitting the groups she was concerned with discipline problems. Thus, it appears that Alice in contrast with many of the Portuguese participants was sensitized for the importance of having pupils work cooperatively rather than being more interested in fostering competitiveness among them. However, whereas work in subjects such as visual arts or social studies might be organised as a small group and cooperative activity, learning in mathematics was essentially individual. Given that mathematical activity was regarded by Alice as a matter of operating with numbers following certain rules, it is hardly surprising that she considered that there is little space for communication and talk among pupils in mathematics.

As an illustration, Alice's account in describing her maths lessons on the very day of the pre-interview follows:

I taught areas and perimeters... It is a theme that had already been dealt in the previous term, but I had to teach it again because I realised through the assessment test that several kids failed in that... I did some exercises on the blackboard... Afterwards, they [the pupils] did some other exercises in their notebooks... and I was monitoring their work individually...

It is worth noting the whole class approach with all the pupils engaged in the same activity irrespective of the fact that the lesson was for reviewing a 'old' theme and that some pupils had already grasped it.

Alice's interactions with the Logo course

Developing competence with Logo

Throughout the course, Alice directed attention not only to activities concerned with the use of Logo in the classroom, but also to those aimed at personal development. For example, she was the only Portuguese participant who presented a Logo extended individual project. Perhaps her relative lack of satisfaction with her job and her willingness to do something else led her to invest time and energy in increasing her own knowledge of and competence with computers and Logo.

Alice's experience with and confidence in using computers were important factors in accounting for her commitment to developing personal expertise with the computers and Logo too. It is worth noting Alice's smooth start-up with the course. In contrast with many participants in the course Alice did not appear to have experienced any kind of anxiety and frustration with the course approach during the early sessions. Entering the course with more experience than the other participants seems to have helped her to feel comfortable and resourceful, thus increasing her self-confidence. This might have acted as a catalyst for increasing her knowledge of Logo and improving her performance. Alice was undoubtedly much more at ease with the computer than the other Portuguese participants, produced more work and came to display more knowledge of Logo programming features than most of them.

The presence of appropriate resources and assistance may have also contributed to Alice's success in building confidence in using Logo. As a consequence of Alice's on-going involvement with the Minerva project, she had at her disposal two computers in her classroom and was offered assistance by one of the members of the Minerva project who also cooperated

with the present research. This meant that she was able to extend her Logo work between sessions, and at the same time was feeling supported and getting reinforced for what she was doing.

A concurrent factor contributing to Alice's growth of competence with the computer and Logo was her autonomous orientation to learning. Emphasis upon the participants' self-direction and creativity appeared to have fitted well with an arts oriented person like Alice. In referring to the activities that stood out for her in the course, she mentioned the development of the Logo extended group project and her involvement with her own Logo extended project. Clearly, Alice enjoyed the freedom and flexibility inherent in this kind of activities.

Linking mathematics with Logo

Alice's involvement in Logo activities during the course sessions was not accompanied by visible signs of excitement. A possible explanation for this fact is that memories of relative unsuccessful experiences with the subject as a pupil were interfering with her success in doing mathematics in the course. One may suspect, too, that with a relatively weak background in mathematics, Alice found some of the mathematical ideas involved in her activities difficult. For example, whilst Alice came across recursion and used it in two or three of her projects, it seemed that she did not articulate the idea at far greater depth than using it as a mere piece of Logo programming.

Nevertheless, the general impression of Alice's emotional response to programming with Logo and exploring mathematical ideas was that she enjoyed it. There seems to be little doubt that the computer and Logo provided a context in which her enthusiasm and confidence with mathematics were maximized. Her satisfaction is well captured by her words in referring in retrospect her own individual extended project:

I spend long hours with it, but I enjoyed it... [...] The computer is something I'm fond of and I enjoy this kind of work. It is fun... Sometimes I had difficulties, but I went back and did it again... Sometimes I felt a little bit disappointed but I didn't give up.. I felt like continuing till I discover what was wrong...

It is especially relevant that Alice mentioned her emotional reaction to her difficulties in programming with Logo. Because the computer was something she was fond of, the mathematical activity in which she was engaged assumed particular relevance and meaning, and she was able to withstand frustration and errors.

One can also relate Alice's engagement in mathematical activity to her motivation to join the course. Recall that Alice expressed discontent with the characteristics of the existing mathematics curriculum and to a certain extent with her own teaching of the subject.

Most significant is Alice's reinterpretation of Logo activity and of what mathematics is about. The focus of her Logo activities in the early course sessions was on the final product. Overall, the general emphasis of her activity shifted from getting things done to the processes involved in getting them. For example, during the fifth session while pursuing a solution for a self-initiated project Alice was challenged to engage in an exploration of circles and arcs and their properties. The following comment in retrospect illustrate the sense in which in engaging in such activity Alice was perceiving her Logo work as of mathematical nature:

I discovered new things through the computer... You know, you do something and then you discover that it is not like that, as it happened with the circle... It's fun...you end up by discovering that there is a relationship between the number of times you repeat and the turning angle...

Implementing Logo in the classroom

Given Alice's initial motivation to use Logo with her pupils, it is hardly surprising that she reacted favourably to the course requirement to implement Logo in the classroom. In addition, her readiness to use computers (enthusiasm, experience and existence of appropriate resources and assistance at her disposition) might have contributed to her favourable reaction.

Interestingly, although Alice was committed and felt at ease in utilising Logo with her pupils, there were no great signs of personal enthusiasm nor did she appear to have made a major investment of time and energy in doing so. The impression I got from Alice's interactions with the course as a teacher was similar to that I had from her as a learner: sympathetic and responsive, but lackadaisical. Her relatively unenthusiastic reaction may be attributed to personality characteristics. Another reason may have to do with the fact that, in contrast with other Portuguese participants, her motivation to use computers in the classroom was not triggered off by a desire to impress colleagues, pupils and parents. She was interested more in a constructive use of the computer than in its cosmetic utilisation.

It must be stressed, however, that Alice remained highly committed to use Logo with her pupils throughout the course. She was even keen in bringing a sample of the Logo work her pupils had developed as part of the course requirement to an exhibition of computers in education organised at the time of the course.

It is worth pointing out some features of Alice's response to my visit to her classroom to introduce the Floor Turtle. First of all, Alice had given freedom to the pupils, within their usual groups, to formulate a problem to solve with the Turtle. In so doing, Alice seemed even not to have pressed pupils to plan their projects, or at least she did not make sure that they had managed to formulate a problem. Thus, during my visit, one of the pupils approached me seeking advice about what his group should do with the turtle, as they had not been able to plan anything yet. A possible explanation for Alice's strategy is that she was interpreting the course emphasis on self-directed learning as allowing the pupils to do whatever they wanted to. It is possible to interpret Alice's approach in the light of her low sense of responsibility over her pupils' mathematical learning too. Alice did not perceive herself as an authority source for her pupils, hence her strong dependence on the textbook. In the absence of either a Logo book or existing routines to guide her she did not use any specific plan for her pupils interacting with the Turtle.

A couple of other features of Alice's approach may be explained in part by a similar pattern of strategies within her mathematics teaching. For example, she had planned enough time so that all pupils in their groups would have the opportunity to work with the computer and the Floor Turtle. Second, while Alice had given the freedom to her pupils to do what they wanted to do with the Turtle, she would monitor closely the Turtle work of each group standing near and direct the group without paying much attention to the other groups in the class.

It is remarkable that I obtained a different picture when I visited her class the second time. This time she drifted away from the practice of having all pupils working with the computer in their groups, each group for a little time, to one approach in which only a couple of groups was allocated to work with the computer for a greater amount of time. A second direction in which she appeared to have moved was that she was able not only to monitor the work of the pupils at the two computers, but also the other pupils' work. Such contrasts, however, may have been the result of the two qualitatively different contexts around which her strategies were centred -- Floor Turtle work and Logo screen work. Without further empirical evidence, the different strategies must be taken as no more than that.

Reflecting upon pedagogical issues

An apparent non-reflectiveness stance is illustrated by Alice's response when asked whether the implementation of Logo in the classroom had led her to reflect upon her mathematics teaching:

No, I don't think so. At the beginning, I didn't know well how the use of Logo would influence the teaching of mathematics... I think I was learning as I was working with them (the pupils), and I was seeing the difference that it would bring...

By providing a generalised realisation rather than focusing on her involvement with the course, it seems that throughout the course she was hardly aware that reflection was one of its important features.

A couple of reasons can be found to explain this apparent lack of reflection. First, it is consistent with Alice's relatively low sense of being in control of pupils' learning. Second, it may be that she was too much concerned with the development of her own competence with Logo to notice implications of its use at classroom level.

Nevertheless, the interest and commitment shown by Alice and the time invested by her in the course activities make it difficult to believe that she went through the course without considering and exploring alternative ways of doing and thinking about mathematics and mathematics teaching. One aspect of this picture can be singled out: her involvement in the development of the Logo group project. In contrast with most of the Portuguese participants, Alice felt comfortable with the course requirement to develop a Logo group project. She was the leading participant, taking responsibility for the topic to be dealt with within the project (measurement conversions), and setting the pace and doing most of the programming during its development. At the end of the course Alice was very positive about the value of the project and about the idea of "thinking together and discussing together", describing it as the course activity that stood out for her.

Shifts in Alice's attitudes towards mathematics and mathematics teaching

There seems to be little doubt that Alice's experience with the course provided her with the opportunity to engage in activities relevant to the development of new attitudes towards computers (and Logo), mathematics and mathematics teaching. First, her exposure to problem-solving with Logo led her to move away from seeing it mainly as a drawing tool to regarding it as a tool to do mathematics. In reporting during the post-interview the kinds of mathematical activities she had been involved during the course she stated:

For example, writing a procedure, the kind of reasoning that leads you to write a procedure... [...] Other things as well... Things that I already knew, but that I used in a different way... it was like learning again...a new way of using and thinking about mathematical concepts...

Second, some shifts in Alice's views of (school) mathematics appeared to have taken place too. Here is how she explained at the post-interview what mathematics is about: "It's a set of rules, concepts, and principles that lead one *to discover things* [my italics] and to solve problems". The fact that she added 'to discover things' to her initially expressed views of mathematics points to a less prescriptive perspective of the subject than the one she held before the course. The same impression is got from her shift from disagreement to agreement with the questionnaire aim expressing the idea that mathematics is a creative subject. On the other hand, her efforts and difficulties in programming with Logo appeared to have directed Alice to focus on the logical aspect of mathematics and come to support an *elitist* view of the subject.

Finally, it seems clear that Alice found in the course resonance for her disillusionment with the existing mathematics curriculum and her reforming zeal to adapt it to children's interests. As a result of that, her attitudes towards mathematics teaching seemed to have been shaken. It is worth noting, for example, that at the end of the course she opted for the uncertain category in answering five of the eighteen questionnaire items addressing those attitudes. The shifts in her opinions about two aims of teaching mathematics are also significant. An area to which she became particularly sensitive was that of the role of pupils in learning. In the post-interview, she spoke of being possible for children to learn mathematical concepts in a different way or even to learn ideas which were not addressed by the current mathematics curriculum, though the realization of this fact was restricted to only one or two facts concerning angles. However, at the end of the course, Alice's practice with Logo in the classroom was still engrossing to allow a full realization about where it was heading in relation to mathematics teaching.

APPENDIX F.4: The case of Diana

Diana's initial attitudes and motives for joining the course

Diana's motives for joining the course

Diana had already been working with "those little things" of Logo with her pupils, but was uncertain about her approach to using it. As she put it: "I don't know whether we're doing it right or wrong...I don't know whether or not what we're doing is appropriate for second graders...". Clearly, she was looking for new ideas that would guide her in using Logo in the classroom, possibly with the aim of changing her usual pedagogical approach. She also expressed some interest in engaging in Logo programming activity that would enable her to develop some programs for children learning mathematics.

Moreover, she was beginning to show some discontent with her teaching of mathematics and thinking of the computer as a possible solution for the problem. She was particularly disappointed because the great majority of her pupils were not responding to her approach according to what she wanted: although they had good marks in mathematics, they showed little enthusiasm for the subject:

...as far as I know mathematics is not well taught in primary schools... [...] The way we [my italics] teach mathematics is not the most appropriate neither to teach them (the pupils) nor to have them enjoying the subject... And that's important... so important that I asked my pupils which were their favourite subjects, and of the 32 pupils only two said that they preferred maths... This is not to say that it's not my fault... Well, I do the best that I know... I haven't had opportunities to learn how to do it in another way... May be the computer is a way to make the teaching of mathematics and teaching in general more interesting, a way of making them to like mathematics... I tell them that maths is fun, but it doesn't help... they don't find it fun at all..

Diana's initial attitudes towards computers

Readiness to use computers

Diana had been using computers with her pupils for about one year. Computers were primarily an entity of "school knowledge". Her interest in and decision of incorporating computers into her teaching was built upon the idea that computers in education were inevitable due to its role in society. Her line of thought was like this:

Computers are the future and children need to learn how to use them. Time will come when it will be necessary for virtually all teachers to come to terms with the fact that computer is here to stay and all will need to be able to use it. It's what's coming, so let me start as soon as possible...

Moreover, she was probably trying to find in the use of computer in her class a form of personal satisfaction and a renewed interest in a job that she seemed to enjoy but that did not offer other perspectives than becoming stale. It is significant that Diana had taken herself the crucial step of buying (with the parents support) two small microcomputers for her classroom.

Orientation to the use of computers in mathematics lessons

In referring to the ways in which she had been using computers in mathematics, Diana mentioned the little software that was available to her -- drill and practice exercises for doing calculations and learning the tables. Despite the fact that she had been using Logo with her pupils she appeared hardly to have envisaged any connection between it and mathematics. Her vision of the use computers in mathematics was restricted by both her perspective mathematics and of teaching the subject.

The use of computers in her mathematics lessons, however, had not triggered a new set of conditions for teaching the subject. She had not risked dramatic changes in the classroom context that might undermine essential aspects of the usual classroom atmosphere and role of pupils in learning. In terms of supporting her pupils' Logo work, for example, she had produced some Logo worksheets with the help of the person (an electrical engineer not an educator) who was assisting her in her innovatory efforts. Moreover, in order that the pupils did not get distracted by the presence of the computer, she managed to get her classroom divided by a wall and the computer work would take place in the 'new' room created.

Diana's initial attitudes towards mathematics

Sensitivity to mathematics

Diana's comments during the pre-interview and answers to the pre-questionnaire rendered her as a person who has liked and felt reasonably confident with mathematics. Interestingly, she had not managed to get a pass in the equivalent to O-level. Moreover, she gave up of pursuing mathematics at the A-level because "it was modern maths". These two facts (together with her participation in the course) led me to interpret her enthusiasm for and confidence with the subject as derived mainly from factors external to the subject. A possible explanation for the establishment and maintenance of Diana's positive self-concept to deal with mathematics is that they were built upon her feelings of anxiety and powerless in subjects traditionally considered of open nature such as language arts (something of the kind "I'm helpless at Portuguese, but I'm good at maths"), and in contrast felt secure in 'mathematical' activity of algorithmic nature. It is interesting to note that in recalling a good moment in dealing with mathematics she focused on a good mark that she had in an examination, rather than something that was intrinsic to the subject.

Views of mathematics

When in the pre-interview Diana was asked what mathematics is about she came up with the following:

What I would say is that mathematics is not a monster, that is a subject that can be liked... I could also say that mathematics is very important, that it is everywhere in everyday life..., because I think that without mathematics you cannot do anything...

The image of mathematics that this comment conveys has strong affective connotations and is associated with Diana's perception that most of her pupils do not like the subject. This comment might typify what Diana would say to her pupils as a response to their little enthusiasm for maths. She went on saying:

I think that mathematics helps to develop reasoning skills, and this is very important because reasoning helps you in many situations in your life outside mathematics... *Apart from* all other aspects that I was put into my head such as doing calculations, solving problems, going to the blackboard...

Here, she is pointing to characteristics of mathematics that stress its logical aspect and emphasises intellectual operations. The expression *apart from* clearly indicates that at the level of theory she was willing to shift away from showing mathematics only as traditional school mathematics. Her answers to the attitude questionnaire, too, suggest that she had begun to break away from a conventional perspective of mathematics. Indeed, alongside an *absolutist* view of mathematics, she appeared to hold an image of the subject that she has to teach as that of a creative and dynamic discipline. I wonder whether Diana had been influenced by Papert's ideas which she had come across in a recent course on computers in education she had recently attended. However, for the most part, her comments during the pre-interview suggest that for Diana, mathematics is essentially synonymous of the mathematics of the school curriculum.

Diana's initial attitudes towards mathematics teaching

Pedagogical mathematical expertise

Given that Diana had not had significant experiences with mathematics other than those she had had as a pupil, it seems reasonable that her perspective of teaching the subject was still shaped by those formative experiences. As a teacher, her experience was almost exclusively

limited to that she had in her current school, and this may mean that her teaching have followed a pattern which has changed comparatively little.

As already suggested, Diana felt that something was wrong with her teaching of mathematics, but obviously did not know how to go about it. She blamed various things, one of which was the lack of opportunities to self-growth. She also referred to the characteristics of the mathematics curriculum as determining pupils' attitudes and/or level of difficulty with the subject. For example, she commented "pupils only have difficulty with maths in the third grade..., you know, there are many topics to be taught..., but in the end they are able to overcome the difficulties".

Aims of teaching mathematics

Like most of the course participants, Diana expressed multiple aims of teaching mathematics. Her choices in the attitude questionnaire placed the affective and practical goals as her primary aims to teach mathematics. Her allusion (in fact, frequent allusions) during the pre-interview and other informal meetings with me to her pupils' negative attitudes towards mathematics may be interpreted as a sign of her willingness to have pupils enjoy the subject.

In the interview, too, she often mentioned the importance of mathematics in terms of everyday life. But she had still a long way to go to have pupils to achieve those former two aims. It seems fair to say, that she also use to give priority to the disciplinary aim, one that is consistent with the ethos of Diana's school. But, I guess, what was really important for Diana was the 'cult of efficiency'. Despite the fact that she did not explicitly mention the curriculum efficiency aim, much of Diana thinking about seemed to be influenced by the prescribed curriculum with emphasis upon high structure and hierarchy. At level of theory, she might strive for other kind of goals, but her instructional techniques aimed at having pupils to perform well in tests. And she managed to do so. As she reckoned most of her pupils have good marks in mathematics. But she also realised that part of her responsibility for pupils' mathematical learning was shared with parents who have a good academic standard to offer extra help at home. As she put it: "I'm lucky because of my pupils' social background".

Pedagogy/teaching strategies

Clearly, Diana's school is an important factors to take into consideration in analysing her pedagogy/teaching strategies. Being a teacher in a private school may mean more subordination to both the head of the school and pupils' parents than in teachers in the state sector normally do. Consistent with this remark is the fact that on a couple of occasions during the pre-interview Diana, in contrast to other participants, referred to the parents as making demands concerning her instructional practices.

Children in Diana's classroom were normally arranged in groups of four, but as she stressed mathematical work was mainly individual. Significantly, she commented: "Sometimes, I propose a group project, but normally it does not result well, because one child is very fast, and the other children are slower and don't understand...". Such comment suggests that Diana encouraged little co-operation among pupils.

On the instructional side, Diana followed the pattern that seems to be the most pervasive form of mathematics lessons among the Portuguese course participants: whole class teaching with no mixture of subject matters. There is another aspect of Diana's teaching strategies that should be mentioned: the business like manner in which she appeared to plan her mathematics lessons. She saw teaching as a series of discrete lessons well planned in advance to deal with and transmit information about discrete topics of mathematics. The following comment which arose when Diana was asked about the way she organises her mathematics lessons illustrates this:

What I do is to put the topics that are easier in the first term... Anyway, the topics to be covered by second graders are not very difficult... In the second term, I teach the 'hundred', the 'thousand' and the roman numerals, and now I'm going to teach the 'time' and the 'hours'... [...] I always try that what I teach is fun... The last thing I taught were the straight lines, and I drew things on the floor to

exemplify... Normally, I play a lot with them... sometimes I make use of themselves ... They also go the blackboard to do things... With the first graders we go to the school yard and they find it fun...

While this concern for making mathematics enjoyable and its teaching informal might be genuine, her mathematics teaching tended to follow a structured and directed approach, an educational approach based upon "tell them and have them practice it a lot" (Davis, 1989³). Although she considered that pupils might have mathematical ideas to offer, she appeared to feel that was risky to have them to put forward these ideas and preferred to give them all they need to succeed in formal testing.

Diana's interactions with the course

Building competence with Logo

On entering the course Diana seemed to be looking for both personal and professional development with Logo. Throughout the course I got the impression that she was feeling comfortable with and committed to the experience, but afterwards I came to see things from another point of view. As an illustration of this, it is worth noting that she would often refer with apparent enthusiasm to her involvement and progress in developing an individual Logo extended project between the sessions. She seemed to be confident that she could develop whatever Logo skills she needed to carry out such a project. However, she never came to present such a project and I now wonder whether she had actually engaged in such activity. It is possible to characterise Diana's behaviour as a form of strategic compliance. She had a respect for authority that normally goes along with assuming a submissive role -- any unfavourable reaction to the course orientation would be considered inappropriate.

When I came to examine the dribble files of Diana's work throughout the course sessions, I also concluded that involvement with Logo programming activities at her own level was limited and her growth of competence in using Logo was moderate. For example, during the sixth session she (and her working partner) still had difficulties in debugging and changing procedures. What forces were at work that might have hindered Diana's own growth with Logo?

A major factor that might have hindered Diana's personal development with Logo was the fact that the course theoretical orientation did not fit in well with her own orientation to learning. The gap between her own learning and the course approach was too big for her to build on her previous experience with Logo. For example, the climate of cooperation and interaction that was encouraged did not suit Diana. Indeed, Diana felt more at ease when was working alone with the computer than when working with peers. On several occasions, she would not join the rest of the group during the coffee break and would continue to work with the computer on her own. Also, one instance was recorded in which Diana dismissed her working peer and went to work alone in another computer. During the development of the Logo group project, Diana assumed almost exclusively the role of a spectator. In evaluating her participation in the course in retrospect at the final interview, Diana commented that during the earlier sessions she had felt frustrated because in working with a computer inexperienced peer she was making no progress and therefore wasting her time. At a later stage of the course, she was also feeling frustrated by her lack of ability to deal with the more complex features of Logo. In other words, at the earlier stage of the course there was not enough challenge, and at the later stage the challenge was too great.

Moreover, Diana seemed to have felt uncomfortable with the course approach emphasising self-directed learning. She needed structure and guidance. For example, rather than regarding my suggestions of Logo activities just as starting points, she tended to view them as exercises to follow very closely. She was never able to set her own learning goals. The following comments made during the post-interview suggests further that she found the course approach

³ Davis, R. (1989). The culture of mathematics and the culture of schools. In *Journal of Mathematical Behaviour*, 9, 143-160.

difficult to cope with: "You know, although I think it is important to have your mind stretched, I was more accustomed to go and learn from the book..."

In short, the course activities came into conflict with Diana's usual methods and expectations of typical classroom practice. As a result, her initial motivation waned, and she disentangled from the experience, if not physically at least psychologically, and this hindered her development with Logo.

Not linking mathematics and Logo

Another way in which the Logo course did not meet Diana's expectations was in the kind of mathematics it had to offer. What the course offered her as not 'proper' maths', and her sense of achievement in dealing with the Logo-mathematical activities during the course sessions was relatively small.

Embodied in Diana's activity during her interactions with the Logo there was a tendency to be preoccupied with practical matters. It was clear that Diana preferred tasks in which there was little ambiguity about what to do and how to do it. Moreover, she just wanted to work on a problem and get it over as soon as possible. As a matter of illustration one may look at the way she (and her working peer) solved the "Playing with Words" task (see Chapter 4). Instead of attempting to write the word ALTO first, Diana focused upon the word ALTO which was to be derived from the first one. The desire to get the task done in the least time possible and the focus on the product at expenses of reflecting upon the processes involved may be further inferred from Diana's decision for replacing the task at hand by substituting a "plain font" format for letters for a "bold" one. In making the task considerably less challenging by removing from it wider applications of mathematics she was interpreting Logo essentially as drawing tool. A related issue was that Diana, unlike other participants, did not resume the task by making use of procedures. It may be that she was pleased because she had solved the task and was not interested in pursuing different avenues to solve the same problem.

In a subsequent session, while attempting the "Investigating Stars" activity (see Appendix D.10), the main objective of Diana was on the visual effect on the screen making use of stars of different sizes. Apparently, she resumed this activity at a later stage in her school. Her account at the post-interview of her 'success' with the task indicates that her main concern was, once again, with the final product at the expense of the meaning and underlying mathematical relationships embedded in it.

Furthermore, it was apparent that she experienced some difficulties as she was solving some of the Logo activities. For example, earlier in the course, Diana could not figure out how to make the turtle draw a four squares grid. Moreover, she never came to grasp and use the most complex features of Logo. Thus, the development of the Logo microworld in which she was engaged with other two peers pegged at a higher cognitive level that she could handle.

Implementing Logo in the classroom

Looking back at her participation in the course, Diana did not hesitate in considering the Floor Turtle work as the activity that stood for her. This included not only the Floor Turtle activities that took place during the course sessions, but also the work she developed for introducing the Floor Turtle to her pupils. Something seemed to have 'clicked' for her with the Floor Turtle. She wanted to borrow it for using it with her pupils, and she became deeply engaged in planning my visit to her classroom to introduce the Floor Turtle. She seemed to have enjoyed feeling creative and successful in trying something totally different from what she used to do.

Her enthusiasm for and interest in my visit to her classroom to introduce the Floor Turtle were enormous. There were some posters on the classroom walls with turtles drawn by the children advertising the visit of the Floor Turtle. All the children were using a "Turtle Day" badge, and one of them had been chosen to act as a turtle and had been dressed accordingly. The classroom atmosphere informal notwithstanding, the teaching that I observed was very formal. Diana had adopted a whole class teaching approach, interacting with the pupils in question and answer manner, and controlling all pupils' interactions with the Floor Turtle. The activities that

she had assigned were devoid of a practical situational context. She was more interested in showing that her pupils were able to evidence their knowledge of the Logo primitives (in English) and of geometrical shapes than in exhibiting that they had an intuitive understanding of what was going on.

As the course progressed, however, Diana's enthusiasm and commitment to using Logo with her pupils appeared to have diminished. At the final interview, Diana commented that her pupils had lost interest in using Logo. Probably, she had also lost interest in having her pupils working with it. When I visited her classroom for the second time, much of her enthusiasm and the atmosphere of informality that I had observed in my previous visit had disappeared. She had selected two pairs of pupils to work with the computer and Logo. While I was observing these pupils, Diana stayed with the other pupils pursuing the usual mathematics lessons (in the room the other side of the wall) mainly working through routine exercises in their books. The pupils working with Logo were trying to reproduce a drawing that was presented in a worksheet. In their attempts they were making use of procedures that they had already defined and that they were trying to retrieve by heart. Given that they did not get the expected results, they got frustrated. It became clear that they were neither accustomed to negotiating solutions nor to experimenting. At a certain stage they decided to drop the Logo work and went on to try the 'cassette with the tables'.

Obviously, the Floor Turtle represented for Diana a way of bridging between the established culture of her classroom and her desire of doing something different. In contrast, in using the screen turtle, something that she had already been using, she was not flexible enough to adopt a new strategy. The course suggestions based upon the idea of having pupils working cooperatively in activities of open-ended nature fitted poorly the highly structured atmosphere of Diana's classroom. Although she saw the need to alter her teaching strategies she was not ready yet to do so. Or may be the Logo culture that the course aimed to transmit was far removed from the usual culture of her school to allow her to make a move.

Reflecting upon pedagogical issues

The image that emerged from Diana was that of a participant little disposed to interacting with and welcoming ideas from her peers. For example, as already mentioned she showed little enthusiasm and involvement with the Logo extended group project, restraining almost exclusively to the role of a spectator. Also, her participation in the group discussions was limited to the occasions in which she was required to talk. Moreover, she did not appear to find it enjoyable to be with the other participants socially at break times. At the final interview, she volunteered the following comments:

I also appreciated the aspect of comradeship... It was a shame that, perhaps because of my personality, I didn't get closer to the other participants... but I think that's important... it's always good to have the opportunity to talk to others especially about new experiences because we live so isolated...

Diana had this conflict too. She might have felt that the course environment had given her the opportunity to interact with other teachers and she seemed to see some value in it, but she found it difficult to respond to that opportunity. Given her lack of participation in co-operative endeavours, it seems that the course did not provide an opportunity for Diana to learn from other participants' interests and opinions, and gradually to disclose her own ideas and argue a point through.

In addition, there is little evidence that Diana's experience with the course led her to reflect upon her own learning in any fundamental way. When I asked her whether her experience as a learner had led to think about the role of pupils in learning, she answered vaguely: "It's always good to be in this side... because we tend to forget what it is like to be learners...". Pushed to be more specific, Diana spoke of "being more interesting to discover things for oneself", but obviously she had some reservations about to do that with her pupils. My impression, however, is that Diana hardly derived any pleasure from discovering things for herself. As already suggested, she appeared to have seen little relevance in the course activities aimed at her

own development, and she might even to have felt uncomfortable with some of the difficulties she had to face in dealing with mathematics.

It should be noted in passing that it was common for Diana to remain indifferent to and even to assess unfavourably her participation in formal learning situations. Recall, for example, her assessment of her pre-service training course. Note also, her comments in evaluating her participation in a couple of computer in education courses she had recently attended: "it was awful... I came from there worse than when I entered...". On entering learning situations, Diana appeared to have a hidden agenda. She wanted to learn and know more, but once she had the opportunity to do so she stood on her head.

Shifts in Diana's attitudes towards mathematics and mathematics teaching

At the end of the course, Diana did not feel that it had met her expectations. In talking about the pedagogical value of Logo in mathematics, she commented: "I think Logo is very interesting, it has a lot of potential... Now, after all this I continue without knowing very well what I can do with it... [...] I don't feel satisfied, *I think I still know very little* [my italics] but it has a lot of potential...".

The course required a new set of attitudes and routines that were highly discordant from her previous experiences and Diana was resentful to that in a variety of ways. For example, in spite of her confidence in her ability to do mathematics and her willingness to do some programming with Logo, she appeared to have experienced some difficulties in engaging in such activity. She did not enjoy the playfulness or exploratory quality of the suggested Logo-mathematical activities either. This was far beyond the usual process of manipulating symbols and practising routine skills. Interestingly, at the end of the course she had shifted her view of the computer from mainly as a calculator device to an object to reason with. However, it should be noted that there were no evident signs that Diana's relatively high self-concept in her ability to do mathematics had been affected.

Her lack of progress and achievement in her own development with Logo was probably detrimental in maintaining her initial level of enthusiasm and willingness to change her conceptions of mathematics and of mathematics teaching. It seems reasonable to conclude that Diana's participation in the course contributed little for her to get an enriched understanding of mathematics, the purposes of mathematics instruction, and to focus on what possibly was going not so well with her teaching of mathematics. Note, for example, the similarity between her response in the post-interview to the question of what mathematics is about:

Either I would say those usual words that everybody says, that mathematics is doing calculations and solving problems or I wouldn't know what to say... [...] Moreover, it would be important to say that mathematics is not a monster, because I know that most people does not like mathematics...

and the answer she gave in the pre-interview. In fact, she appeared more locked into a conventional view of school mathematics after the course than before it. Such conviction did not allow her to perceive Logo as a tool for doing mathematics. When questioned about mathematical concepts and topics which could be dealt with Logo, she said:

With Logo I never tried mathematics. [...] Well, in Geometry I think there are some geometrical shapes, for example third graders have to learn some geometrical shapes... May be pupils will be able to do them by themselves, without being necessary for me to tell them... But in arithmetic I don't see very well...

ATTITUDES TOWARDS COMPUTERS

PERSONAL FEELINGS

- I felt fascinated by computers
- I've always seen it perhaps more favourably than some other people
- Very exciting things
- I look at comp very positively

ADVANTAGES & DISADVANT.

- Very powerful tools of communication
- We forget how to write
- The art of conversation may well go
- I hope that it won't take over and completely destroy the skills that we have like writing / talking
- Many applications, for ex computer shopping

COMPUTERS IN TEACHING

- Comp. could be used for which are more than just a rather expensive work case or skills practicing thing
- Wordprocessing is actually useful and very stimulating for children
- I think that is important that ch. know what comp can or cannot do, if you don't tell it something it can't do anything
- The role of comp is to support the curriculum rather than be an end of itself
- We ought to have at least one comp in every classroom, to enable t. to use it as often as they want
- Without enough machines the ch. get very little hands on
- One of the big advantages was particularly with less able ch. for whom writing is a problem
- Advantages outweigh any disadvantages

COMPUTERS IN MATHS

- To support the curriculum
- To offer things to and present things in an exciting way

Not applicable

Not applicable

Not applicable

- Responds positively to all questions about comp in maths

ATTITUDES TOWARDS MATHEMATICS

PAST MATHS	CRITICAL INCIDENTS	VIEWS OF MATHEMATICS	OTHER
<ul style="list-style-type: none"> ✓ In primary, I did find maths difficult. When it came to apply it to problems I could never work out whether it was adding or subtracting. ✓ In secondary, suddenly (it may well have been a teacher) it all clicked and it became awfully clear. I did applied and pure maths at A level, although I didn't pass. I didn't do enough quest. rather than I had a failure to understand. I didn't find it terribly easy. ✓ Formulas and working things out I used to enjoy. Once I got the idea and it was just rather like crossword puzzles. It was an exercise of mental ability. 	<ul style="list-style-type: none"> It was at an interview to my secondary school. I was taken off to do a test including a maths problem. There was an odd happening that I missed. I remember the generosity of the teacher who was sitting next to me, in helping me get the right answer. As for a bad experience I think doing problems at primary school. I used to hate problems. All of them, as soon as it was problems and as soon as the words were there instead of n°. 	<ul style="list-style-type: none"> The answers are implicit in maths. You don't have to actually make the last statement in an A level question, but it is still necessary to be able to get the right answer ultimately. Maths is about numbers. It's a type of language. An easy language once you get to know the rules. It helps you solve problems and there are applications to things in real life and it is applications in its own right. I think perhaps you do need to be quite reasonably clever to do very well in it, a particular kind of mind. 	
<ul style="list-style-type: none"> Responds positively to all questions about past maths. 	Not applicable	<ul style="list-style-type: none"> Responds positively to 4 of 5 questions about sch. maths. Considers maths as mainly a collection of rules. Expresses views that maths is consistent, and the science of formal structures. Uncertain whether or not you need a logical mind to understand maths. 	<ul style="list-style-type: none"> Responds positively to all questions concerning enjoyment of and confidence with maths.

ATTITUDES TOWARDS THE TEACHING OF MATHEMATICS

PERSONAL FEELINGS	AIMS OF TEACHING MATHS	NATURE OF LEARNING	CLASSROOM CONTEXT
<ul style="list-style-type: none"> • It's probably the thing I teach worst • I think I enjoy teaching maths • Whether children enjoy me teaching maths is another question • The ability to imagine and free thought away from it are perhaps less obvious to me. The boundaries are clearest 	<ul style="list-style-type: none"> • To have a numerate population • It's something that can be fun and so it's as good a reason as any for teaching it • It does have very valuable applications for future careers • Teaching basic principles and the ability to handle numbers in primary school is very important. 	<ul style="list-style-type: none"> • The challenge in teaching is to find the different way of looking at the problem and not think that there's only one way of doing it • It's a challenge trying to work out how best to put a concept • In the primary, there is much more emphasis on abstract operations rather than concrete ones which is a weakness because you can't expect even ch. up to 11 to be operating completely abstractly • Children's concepts in maths are perhaps more personal than many other subjects. • I've always tried to teach a child adding up the way she understands it. Her understanding may not be the same for all the ch. in the group • I think I serve the individual ch best on an individual basis. 	<ul style="list-style-type: none"> • I think a scheme is only an aid to teaching mathematics • It would be fool hardy to expect a scheme to fulfill everything well • Pupils are grouped basically by ability. The group may well change. It's useful to have someone who's quicker and would be someone who'd slow • If we're doing something which they all seem to be unable to then they are put all together. • It's very rare, I think that we do anything on a class basis all together, unless it's a revision exercise • It's useful to have pictures or apparatus or whatever to support the understanding
Not applicable	<ul style="list-style-type: none"> • A tool for everyday life & foundation for further maths are the most important aims, followed by the dev. of reasoning skills • Doesn't consider appreciation and curriculum as important aims 	<ul style="list-style-type: none"> • Expectations regarding to 2 questions related to learning of maths, and he is uncertain about others. • He doesn't see ch. as being able to discover things by themselves • Responds positively to 2 questions: There is more than 1 method way to get a solution, and doesn't emphasise the 	<ul style="list-style-type: none"> • Pupils discuss ideas and work cooperatively but tasks are directed by teacher • Follows textbook closely and demonstrates procedures

	FEELINGS	AIMS	LEARNING	SUPPORT	TIME PERIOD	PUPIL ABILITY	EVALUATION	REFLECTION
JOHN	Teach worst - enjoy teaching Ability to imagination less obvious	Numerate Fun Future Cereals	What did I do to put a concept But I did not do it I did not do it I did not do it	Not expect this I did not do it I did not do it I did not do it	Scheme is only I did not do it I did not do it I did not do it	Shane a day I did not do it I did not do it I did not do it	Hardly is up I did not do it I did not do it I did not do it	about m. I did not do it I did not do it I did not do it
JOSEPH	Each conference Neglected male I have had a very bad day	Enjoyable - Surrounding Patterns	Stimulate to I did not do it I did not do it I did not do it	I can make it I did not do it I did not do it I did not do it	Butter teaching I did not do it I did not do it I did not do it	2 1/2 - 3 h. a week I did not do it I did not do it I did not do it	All saying it I did not do it I did not do it I did not do it	I can understand I did not do it I did not do it I did not do it
DEBBIE	I happen to like I did not do it I did not do it I did not do it	Ch. need to know I did not do it I did not do it I did not do it	What they get I did not do it I did not do it I did not do it	Ch. need to know I did not do it I did not do it I did not do it	Midfield I did not do it I did not do it I did not do it	2 1/2 - 3 h. a week I did not do it I did not do it I did not do it	Like myself I did not do it I did not do it I did not do it	I can understand I did not do it I did not do it I did not do it
DAVID	I am probably very good at it I did not do it I did not do it	Enjoyable - Socially Patterns	Ch. need to know I did not do it I did not do it I did not do it	Ch. need to know I did not do it I did not do it I did not do it	Midfield I did not do it I did not do it I did not do it	2 1/2 - 3 h. a week I did not do it I did not do it I did not do it	Like myself I did not do it I did not do it I did not do it	I can understand I did not do it I did not do it I did not do it
MARK	I would like to teach the best I did not do it I did not do it	Ch. need to know I did not do it I did not do it I did not do it	Ch. need to know I did not do it I did not do it I did not do it	Ch. need to know I did not do it I did not do it I did not do it	Midfield I did not do it I did not do it I did not do it	2 1/2 - 3 h. a week I did not do it I did not do it I did not do it	Like myself I did not do it I did not do it I did not do it	I can understand I did not do it I did not do it I did not do it
PAUL	I would like to teach the best I did not do it I did not do it	Ch. need to know I did not do it I did not do it I did not do it	Ch. need to know I did not do it I did not do it I did not do it	Ch. need to know I did not do it I did not do it I did not do it	Midfield I did not do it I did not do it I did not do it	2 1/2 - 3 h. a week I did not do it I did not do it I did not do it	Like myself I did not do it I did not do it I did not do it	I can understand I did not do it I did not do it I did not do it
KARIE	I would like to teach the best I did not do it I did not do it	Ch. need to know I did not do it I did not do it I did not do it	Ch. need to know I did not do it I did not do it I did not do it	Ch. need to know I did not do it I did not do it I did not do it	Midfield I did not do it I did not do it I did not do it	2 1/2 - 3 h. a week I did not do it I did not do it I did not do it	Like myself I did not do it I did not do it I did not do it	I can understand I did not do it I did not do it I did not do it

FEELINGS	AIMS	TEACHING	LEARNING	SUPPORT	TIME & ORGAN.	PUPILS' ACTIVITIES	EVALUATION	Reflection
Like teaching Tense Want pupils like maths	My aim is to help them learn maths easily and enjoy it	Like to create a relaxed atmosphere for pupils to work in their own way	Like that they enjoy to learn for themselves with help each other - learning from each other	Blackboard Maps Spreadsheets Calculator Ruler Compass	Like to have them in groups Individual work and collective concent on maths more with me	Like maths about 10% of class & home	Homework Worksheets	3
It's not the kids I like I don't have any difficulties I enjoy teaching now	Basics Learning skills Basics - Foreign Language	I think the same as that I want to be a teacher in a school I'm going to be the student of maths	Maths made by pupils to make things...			Pupils are happy to learn maths to come to school		I think I'm happy for the last 10 years of my life
	To make a change of learning to maths in a different way	We start from what is known and go on to what is new I try to see if pupils can do it on their own I try to help them	lots of practical calculations Magic Square	Time constraints due to 10 min 10 min a day	Enthusiasm & Happiness Pupils like maths	It's also important to have a good relationship with pupils		
I don't succeed in explaining maths	Reasoning - Foundation every day	I think I already know a lot about maths				Pupils like maths		It was very difficult to have the maths class One of the reasons was the lack of resources
I like to be in the middle of the class I like to be in the middle of the class	To learn the maths easily and enjoy it	I like to be in the middle of the class I like to be in the middle of the class	Sometimes, I learn a little from pupils	Maths made by pupils to make things...	Ch. groups & non-verbally not in same group - long time to do it	Happy to learn maths easily and enjoy it	Tests Drilling	Always have a good relationship with pupils I don't like to be in the middle of the class I like to be in the middle of the class
I'm no diff. in the middle of the class	Foundation every day	I think I already know a lot about maths	I need a lot of concentration	We have maths	I cannot cope with a class of 30 pupils I try to do it on my own	Happy to learn maths easily and enjoy it		It was very difficult to have the maths class One of the reasons was the lack of resources
From the end of the class I try to be in the middle of the class	Foundation every day	I think I already know a lot about maths	I need a lot of concentration	We have maths	I cannot cope with a class of 30 pupils I try to do it on my own	Happy to learn maths easily and enjoy it	Tests Drilling	Always have a good relationship with pupils I don't like to be in the middle of the class I like to be in the middle of the class
I could like to be in the middle of the class	Foundation every day	I think I already know a lot about maths	I need a lot of concentration	We have maths	I cannot cope with a class of 30 pupils I try to do it on my own	Happy to learn maths easily and enjoy it	Tests Drilling	Always have a good relationship with pupils I don't like to be in the middle of the class I like to be in the middle of the class
I don't like maths	Foundation every day	I think I already know a lot about maths	I need a lot of concentration	We have maths	I cannot cope with a class of 30 pupils I try to do it on my own	Happy to learn maths easily and enjoy it	Tests Drilling	Always have a good relationship with pupils I don't like to be in the middle of the class I like to be in the middle of the class
I don't like maths	Foundation every day	I think I already know a lot about maths	I need a lot of concentration	We have maths	I cannot cope with a class of 30 pupils I try to do it on my own	Happy to learn maths easily and enjoy it	Tests Drilling	Always have a good relationship with pupils I don't like to be in the middle of the class I like to be in the middle of the class
I don't like maths	Foundation every day	I think I already know a lot about maths	I need a lot of concentration	We have maths	I cannot cope with a class of 30 pupils I try to do it on my own	Happy to learn maths easily and enjoy it	Tests Drilling	Always have a good relationship with pupils I don't like to be in the middle of the class I like to be in the middle of the class
I don't like maths	Foundation every day	I think I already know a lot about maths	I need a lot of concentration	We have maths	I cannot cope with a class of 30 pupils I try to do it on my own	Happy to learn maths easily and enjoy it	Tests Drilling	Always have a good relationship with pupils I don't like to be in the middle of the class I like to be in the middle of the class
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	BEHAVIOUR	AIMS	TEACHING	LEARNING	SUPPORT	TIME PROGRAM	PUPILS' ABILITY	EVALUATION	REFLECTION
TANIA	The main problem pupil with diff. for which he takes some of his time justifying himself to work on long.	Everyday life Intellect. develop & academic	Not interested in many lessons Lack of motivation	What ch. mean to what they learn better	All material to count and to concern Basic st. things day heading for ch. learning Ch. like st.	More time for language	In general all	T. has to investigate in pupil self-corr.	T. has to investigate in pupil self-corr.
	At this level the no diff. and the I'm able to get all little matters I'm interested in long what I'm interested in the	Foundation - a everyday life - to be motivating reasoning	We're to give access to things to be motivating The cat. in rest many pupils, I think, there is too time to rest.	All learning is a faith all T. says and you believe					I tried to make the idea that in a program of approach + approach. for subject - learn as
JOANA	I like to 4. in I feel at home. confident to teach the basic to 10. + 11. + 12. I feel + mature	It's a subject related to every day life. Teaching day life	I've a plan I try pupils learn the very common themselves. Concise the main lesson	Not only the adopted book like these things very much. Materials are clear and	Every day I have a monthly plan. Ability to work with either on groups or individuals.	Take on. My own continuous life as a May other reading. If ch. are well prepared I'll		The class I had with pupils didn't lead me to reflect. The fact of being a teacher made me reflect. I was a little bit of a teacher.	The class I had with pupils didn't lead me to reflect. The fact of being a teacher made me reflect. I was a little bit of a teacher.
			First I need to explain, always concerning.	Now I'm probably try to lead the to do work					

EMILIA	The only way to have a lot of diff. on whether pupils are in.	Everyday life To open way to abstract ch. on	With 1. math, through game I try things which are related to real life. I try new concept through a problem	Ch. don't remember even the table what is diff. for 1 ch. they not to diff. for another ch. to like discovery	Materials from book not much	Everyday - time depending on pupils 10-12 hours. Works in groups to learn more to discovery	Normally like different levels. Diff. due to lack of concentration or motivation	Show them that they're able. Really not - only because parents	Reflected about math, simple - complex, animals, maps
	I like to 1. long but I prefer to be using I can know these better. I was the 1. in 4. on a way. The 1. concerned to using	We have to take it all as ch. use. Foundation - interest is everything	To 1. how to do the most interesting. Start with open to interest. authentic concept.	Ch. come to school already know already how to count. Ch. like discovery					